Mechanical World

AND ENGINEERING RECORD

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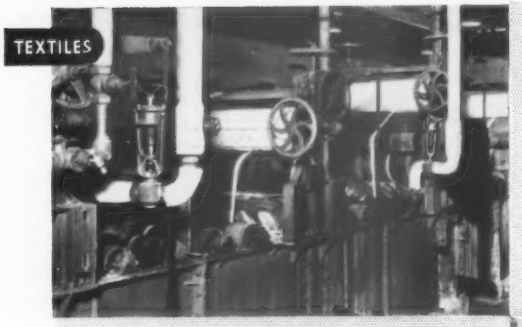

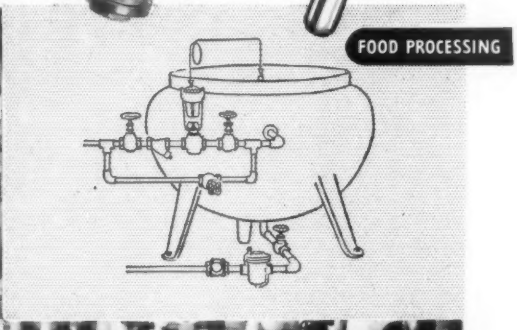

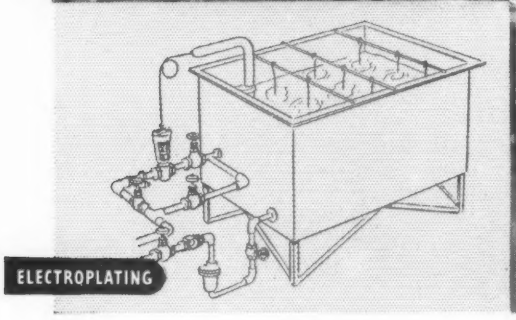

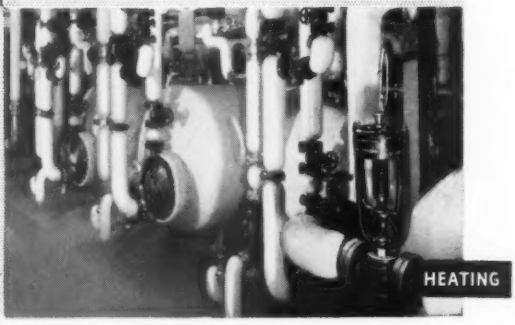

The DRAYTON VT self-operating controller

VT 11

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Mechanical World — March 1959

The Synthesis of Genius

THE work of genius is as evident in science and technology as it is in art, literature and music. The great men and women of the past are famous for their works; creations which were peculiarly their own. Today the great achievements in science and technology have become less the work of single persons and more of teams of specialists, the members of which, if there is no genius among them, contribute the results of good mental power devoted to one particular branch of study. The work of a team is thus compounded of specialization and co-ordination within the team, and not usually of a number of specialists linked by a co-ordinator. That is not impossible but it is not likely, for a successful co-ordinator would be of the order of genius and his team would be assistants rather than collaborators. There have been examples of this.

The great bulk of work is done by teams of specialists who know enough of each other's activities and problems to be able to fit their own contributions neatly enough into the pattern of the creation as it is built up. The quality of the result is a measure of the compatibility of the co-ordination, whether it is mutually stimulating to best endeavours and, most important, to original work, or whether it contains unresolved conflict and no more than barely workable compromise. The former leads to innovation and development if not to something higher, whereas the latter is at best capable of mere repetition and is better done to rigid specification.

Whenever everything involved can be thoroughly understood by one brain then the possibility exists of the result being as good as the ultimate capability of that particular brain. When the capacity for understanding has to be shared by several brains then the result may be more than mediocre up to the point where the efficiency of co-ordination matches the deficiency of genius.

For example, in the simple case of building a bridge, a constructor of genius in both architecture and engineering would produce a permanently satisfactory structure. An engineering genius collaborating with an architectural genius would do as well. But a competent engineer collaborating with a competent architect would produce something which matched only the moment in the history of which they were a part, something fashionable. Separate in this way the more complicated examples of the present day and one finds either genius or the lack of it.

The clue to success in the co-ordination of specialization lies in the overlap between different activities and interests. The exclusive specialist is clearly not of much use except when his terms of reference are entirely within his own field. The useful team specialist knows where his field lies in relation to the rest of the world and knows the fundamental links and how they operate. A good deal has been said about broadening scientific and technical education with this in view and the Cambridge model has often been quoted, and as often dropped because it is framed for particular abilities. The principle must, however, be universal, otherwise the acquisition of links will be hapazard and as often as not contradictory. Technical education is in a melting pot just now, and just as there is good reason for devising examinations which confirm abilities rather than submerge them, so is there reason for imparting knowledge in relation to its context to enable it to be used readily within a team and not locked impotently away.

LOG SHEET

Buried Unarmoured Cable

A quantity of insulated and sheathed low voltage cable has been supplied by Siemens Edison Swan Limited to the Midlands Electricity Board for underground installation. The cable has three sector shaped cores and a concentric copper conductor as the neutral. There is, as yet, no established practice governing the use of unarmoured cable in the ground. Consequently, for safety reasons, it is desirable to have a concentric type of cable, thus maintaining an outer metallic envelope for the live cores. This unusual construction is likely to be used increasingly as protective multiple earthing is extended in rural areas. In this system, the concentric copper conductor is earthed at the sub-station and on each consumer's premises, and would normally be protected over its whole length by a p.v.c. sheath.

It is seven years since Siemens Edison Swan Limited manufactured the first p.v.c. insulated mains cable in this country using shaped conductors. The main incentive for the use of p.v.c. cables is lower overall installation costs because certain designs are cheaper than the corresponding paper cable. This type of installation is little affected by the presence of moisture, there are no compound migration troubles, and the resultant cable has a reduced weight and greater flexibility. Ultimately, it should also be possible to dispense with the use of heating equipment during jointing. The jointing techniques that can be adopted with this type of cable should simplify operation and further reduce the cost of the complete installation where supply engineers are prepared to dispense with heating equipment for jointing.

Process Control by Computor

The first transistor electronic digital computor designed to provide fully automatic control of many industrial processes is being developed by Ferranti Limited. It is about the size of two small office filing cabinets and the first production models are expected to be available in 1960. This will be the first time that a computor of this type designed for process control will use transistors instead of the conventional thermionic valve, and, as a result, will only measure approximately 4 ft × 4 ft × 2 ft.

At present in the prototype stage it is technically known as the PCTC (Process Control Transistor Computor). The transistor logical circuits in the computor have been thoroughly tested and an experimental model has controlled a machine which simulates a plant process for more than 2000 hr operations without component failure. Additional vibration and temperature tests have also been carried out to simulate the most rigorous conditions the computor is likely to meet in industrial use.

Designed for the control of a variety of industrial processes in power stations or chemical plants, transistors, core stores and printed circuits are employed in this new computor to ensure reliability and robustness in unusual operational conditions

The computor is being specifically developed as the centre unit in control systems for a variety of industrial processes, such as may be found in the power, chemical, oil, gas and steel industries. Babcock & Wilcox Limited and their associates Bailey Meters & Controls Ltd. are currently investigating with Ferranti Limited the feasibility of using this new computor for the control of boilers during start-up and shut-down.

Probably the most important factor is that this computor opens the way for fully automatic control of many industrial processes because it can operate continuously for long periods under arduous industrial conditions without the necessity of regular shut-down for preventative maintenance.

Not only will this type of computor calculate alterations that have to be made in any process, but also provide the control signals to automatically carry out these alterations. The price of the new computor will probably be in the range of £20,000—£50,000, depending on the size of the installations.

Silicone Rubber

A new type of oil resistant silicone rubber, Silastic LS-53, is now being used by Dunlop for various components in the aircraft industry. Silicone rubber is normally somewhat vulnerable to the swelling

METALLURGICAL LABORATORIES.—Edward Pryor and Son Limited, Sheffield, have recently moved into these newly built and equipped laboratories. The picture shows the three laboratories—the microscopic laboratory and balance room, the general chemical analysis laboratory and the rough work laboratory. The microscopic laboratory has an adjoining photographic dark room. The main use of the laboratories is for metallurgical quality control of incoming raw materials. The old laboratory, which has been in use for nearly twenty years, is being converted into a new cost office

action of oils and fuels, particularly the synthetic type oils used in the modern high speed aircraft. Silastic LS-53, a fluorinated silicone elastomer, is notably superior in this respect and is suitable for use in a wide range of aircraft oils and fuels, including mineral and synthetic diester lubricating oils, mineral and silicate ester hydraulic oils, and petrol and kerosene type engine fuels. It also has excellent low temperature flexibility characteristics and will function in service at temperatures as low as minus 60°C. Although its resistance to heat ageing is less outstanding than that of standard grades of silicone rubber, it can safely be used in temperatures of up to 200°C.

Proving Machines

A method for proving theoretical propositions by means of electronic data-processing machines has been worked out by a group of Swedish scientists. It is claimed to be the first successful attempt to perform mechanically such intellectual work as is sufficiently advanced to substantiate evidence in mathematics and other "exact" sciences.

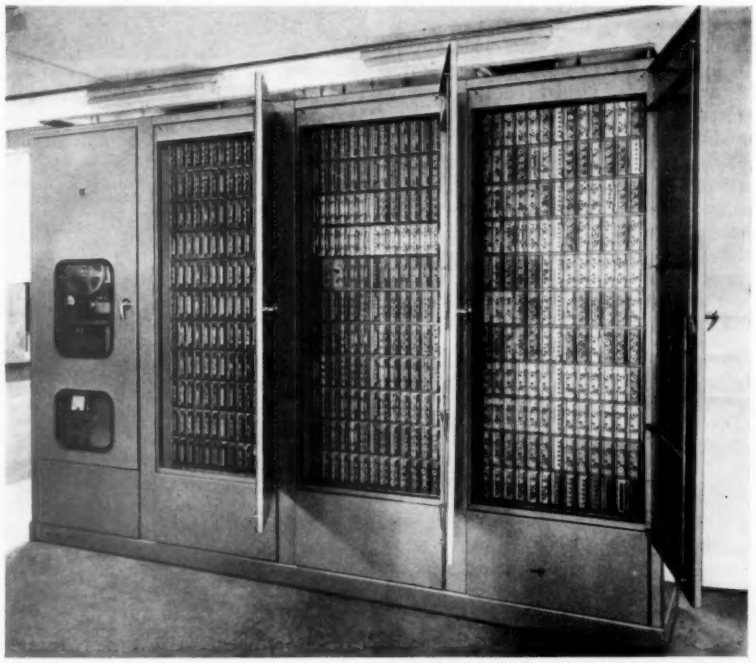
A tape with a code containing the proposition to be proved and the given axioms for the theory in question is fed into the machine. Working on this programme the machine then automatically builds up and prints the demonstration on another tape. Any proposition which is a logical consequence of given axioms, can in principle, be demonstrated in this way.

The method, which lends itself to considerable improvement, has been developed and adapted for the Swedish Atvidaberg Company's Facit EDB data-processing machine by Messrs. Dag Prawitz, Håkan Prawitz and Neri Voghera. It is based on recent contributions in the field of predicate logic, including a doctoral thesis presented by Dr. Stig Kanger of the Stockholm University.

Simpler and less complex logical principles have previously been processed mechanically both in Sweden and abroad.

Shaft Seal Life

The compact mechanical shaft seals, Types 4 and 5 in the standard range supplied by Crane Packing Limited of Slough, were developed for high pressure services. The flexible rubber member incorporated in their design is fully supported against the collapsing effect of high pressures and also compensates for a maximum of 0·125 in. free axial movement, up to 1° of mal-alignment of the fixed face and up to 0·010 in. eccentricity of the shaft. Two other features in the design are smooth exterior contours and a minimum number of components in contact with the fluid. An example of their successful operation comes from the Grimsby Ice Company Limited, where a 10 in. Type 5 seal, installed in an ammonia compressor for ice production, running at a speed of 250 rpm, is still in use, having completed four years and nine months of satisfactory service.



MACHINE TOOL CONTROL.—A prototype equipment for the numerical control of machine tools has been under test at the Rugby Works of The British Thomson-Houston Company Limited. This includes a computor which computes the correct path for the cutter from ordinates taken from the manufacturing drawing, making automatic adjustment for the size of the cutter. The output from the computor is recorded on a magnetic tape which, when run through a tape-reader and control unit on the floor of the shop, will produce signals to control the machine tool automatically. Once the tape has been made it can be used as often as required

Unique Computor

The new electronic digital computor installed by British Railways in the Physics Division of their Research Department at Derby is unique in this country. It is an Elliott 402F computor and is one of only two such machines in Europe. It is a general purpose, automatic, binary computor, designed primarily to tackle scientific and engineering problems in which the mathematics are either too complex or too lengthy to be performed by desk machines. Its use also considerably reduces the time taken in the comparatively straightforward computational work which is a feature of research.

The computor has a medium size memory which enables it to store and perform operations on over 4,000 numbers simultaneously, the input and output of data being by paper tape. An additional feature has been provided in that floating point arithmetic can be used; this permits greater accuracy in a far bigger range of numbers. The speed of the computor is such that pairs of numbers, each of nine digits, can be multiplied at the rate of 300 in one second.

It is intended that numerical calculations will be made on vibration problems, including, for instance, those concerned with the improvement of passenger coach comfort, the analysis of stresses in structures and bridges, and problems relating to the development of continuous braking for freight trains, to assist engineers in design and testing. A further field is that of linear programming, which is of interest in statistical enquiries, such as those involving the determination of

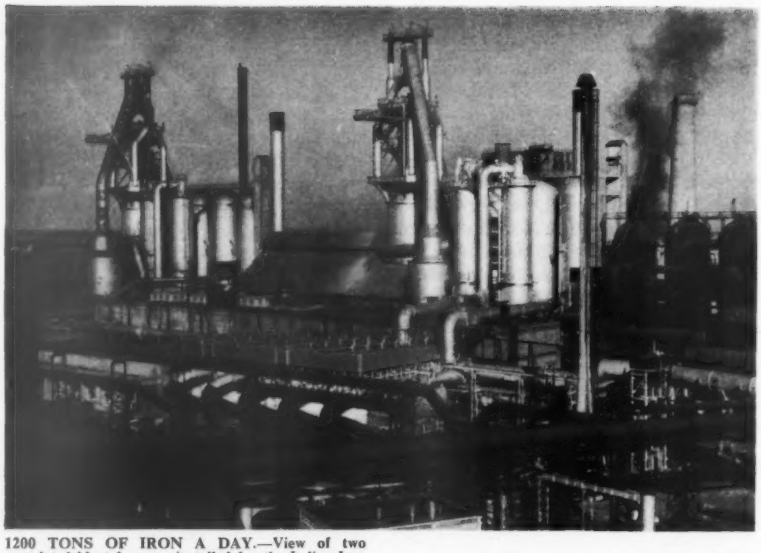
optimum conditions where many variable factors are concerned, e.g. the most economic way of carrying out a complex set of wagon movements.

Trends in Welding

A steady tendency to combine various welding processes to form something which was better than any one of the constituents was the belief expressed by Mr. John Strong, Chief Executive Director of British Oxygen Gases Limited, in his presidential address to the Institute of Welding. Perhaps, in time, instead of a dozen processes each possessing individual advantages over the others, we would have three or four. This would at once permit further rationalization of automatic welding head designs and a greater standardization of electrical power supply equipment. It was possible to see this coming now in the automatic and semi-automatic welding heads which would cater for four or more of the current processes, and a similar trend was appearing in the various forms of electric power supply. Handling gear, including jigs and manipulators, was being steadily rationalized and standardized in design while covering a wider field than ever before.

In automatic welding also, Mr. Strong considered that we would see more and more of the complete welding installation and the complete machine. It was possible that equipment would become more intricate in itself in order to have a more universal and simplified application and if this happened, the need for a complete machine to operate to a guaranteed performance would become increasingly apparent.

Mr. Strong felt that it would perhaps be wise to set out now to provide the greatest rewards to those who carried forward the intelligent rationalization of processes, welding equipment, materials, electric power supply equipment, jigs and manipulators; and especially those who achieved the most effective and universal, yet compact, set of processes and equipment. Great encouragement was also necessary to those who might provide an ideal semi-automatic process. The introduction of this would relieve the struggles of the designers of fully automatic equipment and manipulators whose machinery had to be capable of handling both the one-off and the multiple job.



1200 TONS OF IRON A DAY.—View of two completed blast furnaces installed for the Indian Iron & Steel Company Limited at Burnpur by Ashmore, Benson, Pease & Company, Stockton-on-Tees, members of the power-gas group. The furnaces, with hearth diameters of 25 ft are capable of an output of 1200 tons of iron per day. Both furnaces were completed ahead of schedule. The contract, amounting in value to £3,000,000, was part of the Indian Iron & Steel Company's expansion programme by which the present output of the company will be more than doubled to meet India's present five year plan industrial target. The consulting engineers are the International Construction Company of London

18,000 kVAr Capacitor Bank

The largest industrial shunt-connected capacitor bank in the British Isles is to be found at the calcium carbide factory of The Distillers Company Limited, Kenfig Hill, Margam, South Wales. This recently completed installation was essential in order to avoid the penalty imposed by The South Wales Electricity Board when the average monthly power factor falls below 0·95 lagging. The 18,000 kVAr capacitor bank raises the average monthly power factor above the required limit and it is estimated that a £30,000 annual saving will result. British Insulated Callender's Cables Limited, manufactured the 72—250 kVAr tank-type capacitors comprising the bank, which were subsequently installed by British Insulated Callender's Construction Company Limited.

The main load of the factory is derived from the three calcium carbide electric arc furnaces and the capacitors are connected as near as possible to the furnace transformer primary busbars. Two 10 MVA 33/11 kV transformers, which supply the auxiliary load of the factory, are connected to these busbars via 33 kV oil circuit breakers. A 9,000 kVAr capacitor bank is connected to the secondary side of each 10 MVA transformer and the 33 kV circuit breakers are used to switch each section. The breakers were uprated to 750 MVA breaking capacity as an added precaution.

Separating Blast-furnace Slag

Blast-furnace slag is one of the steel industry's biggest by-products; nearly as much slag as iron is tapped from the blast furnace, and the quantity of slag produced annually by British ironworks amounts to the formidable total of more than ten and a half million tons. Whether it is used or dumped, this vast tonnage has to be removed.

Slag is really a synthetic mineral, and for many purposes it can replace natural stone. The advantages of using slag in this way are various; the national economy benefits, and the landscape is spared the extension of slag-heaps and quarries—a two-fold gain.

Nevertheless, about half the slag made in this country is tipped to waste. There are various reasons for this failure to make use of a potential raw material: in some areas transport costs make slag more expensive than easily accessible natural rocks; and sometimes the slag itself is judged unsuitable on technical grounds. The defect that gives most trouble is excessive porosity, and it is here that the slag separator (the subject of Patent Application No. 23104/57)

developed by BISRA'S Chemistry Department may prove useful.

The separator, devised to provide a cheap and simple method, makes use of the winnowing action of an air-stream. The air-cooled slag is first crushed and graded fairly closely to size. The crushed slag is allowed to fall under gravity through a transverse air-stream. The particles are blown sideways, the lighter and more porous ones further than the heavier (denser) ones, which have greater inertia. An upright blade placed in the path of the fan-shaped stream of falling slag particles serves to direct the lighter and denser fractions into separate hoppers. The amount of separation depends, of course, on the distribution of bulk density in the slag; this can easily be determined in a laboratory separator. The equipment is portable and has few working parts that need to be maintained or replaced.

National Lending Library

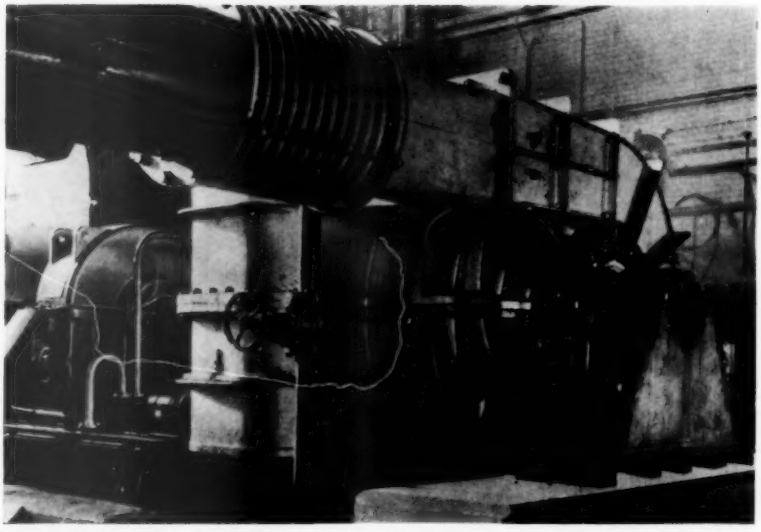
The Department of Scientific and Industrial Research will take over part of the former Royal Ordnance Factory at Thorp Arch, near Boston Spa, Yorks, for the use of the new National Lending Library for Science and Technology. Present proposals indicate that the library will begin operating at Thorp Arch in 1961 and become fully operational during the following year. Existing large single-storey buildings will be converted into offices and book-stores, and the site provides adequate room for expansion in the future.

The new library—the nucleus of which already exists in the D.S.I.R. Lending Library Unit now at Chester Terrace, Regents Park, London—will cover all subjects in science and technology, except for some fields of medicine. It will take over the responsibility for the lending service now provided by the Science Museum Library, which in future will concentrate on serving the needs of the enlarged Imperial College of Science and Technology. It is also taking over some of the literature now held by the Science Museum Library.

The present Lending Library Unit has been collecting literature for the National Library since 1957. It already operates a loan service for Russian literature which is being progressively extended to cover publications from other countries. Eventually much of the scientific and technological literature in the world will be included in this collection, to make it the most comprehensive of its kind in the United Kingdom.

The new library in Yorkshire will make its unique collection available to research, industrial, educational and other organizations by loans and photographic reproduction. Its primary objective will be to encourage the greater use of scientific and technical literature. One important activity will be the expansion of work on the translation of Russian scientific literature, now organized by the Lending Library Unit in collaboration with the National Science Foundation in the United States.

TESTING ROCKET MATERIALS.—A new graphite-base material is here seen under test in a chamber at one of the Union Carbide International Company's development laboratories. Positioned in a jet of exhaust gases travelling at five times the speed of sound from an oxygen-kerosene flame (note characteristic diamond-shaped supersonic nodes), the conical specimen reaches a white heat of approximately 5,000° F in a matter of seconds. Conventional graphite erodes beyond tolerable limits in about eight seconds, but materials have already been produced that hold dimensions ten times longer, and others are being developed which will hold their dimensions on even longer cycles—well beyond the normal operating requirements of rocket engine components



COMPRESSOR FOR SUPERSONIC WIND TUNNEL.—This Rugby-made compressor has been put into service at the College of Aeronautics, Cranfield. It operates at variable speed over a wide range of pressure ratios to provide varying Mach numbers in a small high-speed supersonic wind tunnel. The compressor was designed by the A.E.I. Heavy Plant Division for use with two existing 550-hp, d.c. motors driving in tandem through speed-increasing gears, providing a maximum of 8000 rpm for the compressor. The aerodynamic solution was found by providing a double-flow and single-flow path for the air within a single cylinder, the first stage of compression thus being accomplished by a double-flow impeller followed by two single-flow impellers, with intercoolers between the first and second stages of compression. This arrangement reduces the rotor end thrust, and therefore the size of balance piston. This minimizes the amount of air leakage. The compressor casings are of welded-steel construction throughout

Petroleum Chemicals Plant

The new £10 million petroleum chemicals plant at the Esso Refinery, Fawley, will produce two principal chemical feed stocks, butadiene (42,000 tons per annum) and ethylene (40,000 tons per annum). These products are being piped to adjacent factories. The International Synthetic Rubber Company is now manufacturing type GR-S synthetic rubber from butadiene whilst Monsanto Chemicals Limited and Union Carbide Limited will produce polyethylene and ethylene oxide derivatives respectively when their new plants are completed this year.

The new chemicals plant, which covers an area of 600,000 sq ft within the Esso Refinery has been built to help meet the increasing demand for organic chemicals. A particular feature is the use of air coolers on a large scale for the first time in an oil refinery in this country. These coolers are a big step forward in the prevention of water pollution.

Fig. 1 (left).—Leaders of specialist groups meeting to discuss design projects

Fig. 2 (above).—A discussion on appearance design

Appearance Design in Action

How a product design centre is organized and how it operates. Appearance design is in equal partnership with the technical, production, marketing and economic functions

APPEARANCE design is not something that can be done apart from the technological and economic activities which, co-operatively applied by a team of experts, go to the creation of a product. For complete success in manufacture, marketing and product performance the appearance designer has to work so closely with the other specialists that he inevitably becomes one of the team. Because of this, and in the belief that appearance designers should be part of a technical team living with engineers, works people, costing experts and so forth, The General Electric Company Limited has set up an Appliance Design Centre which can undertake the whole of the work involved in the creation of new designs.

At the inception of a project the first function of the Appliance Design Centre is to decide the brief to which it is to work. This involves market research and product research besides many other considerations. The functions which the article is to perform, the features it is to incorporate, the competitive price range, the quantities to be produced or the rate at which it can be produced, have to be resolved as well as an assessment made of the markets in which it is likely to sell.

Having decided on the product and the economic factors pertaining it is necessary to assess its technical design—the performance required, the mechanism needed to give that performance, the feature to be provided and how to give them at minimum cost. Materials and finishes to be used, manufacturing processes, plant, equipment and tools also have to be considered apart from external appearance and cost. This latter point involves finding the minimum cost in materials, processes and tooling and, where necessary, influencing the design to make the best use of existing plant and equipment and processes already familiar to the factory in which it is intended to produce the article.

The centre is made up of a number of departments comprising cost and information, technical design, mechanical design, appearance design and planning engineer.

Fig. 3.—Appearance design department

Fig. 4.—Model-maker constructing appearance prototype

Fig. 5.—Prototype workshop

Fig. 6.—Precision check of machined prototype component

Fig. 7.—Measuring the speed of a refrigerator motor on test

Cost and information

The cost and information department collects from the economic and marketing research unit information regarding market possibilities. It collects from the sales organization information regarding the possible share which the G.E.C. could hope to enjoy of that market. It is able to determine the prime cost (i.e. cost of material and labour) of competitive products already on the market. It can also advise other members of the centre regarding the probable cost of manufacture of possible alternatives which they are discussing. Finally, when a design has been completed, it can estimate the prime cost and show a comparison between that and the competition which has to be met.

In this connexion it is important to note that this department confines itself to prime cost. It does not attempt to give factory cost. This is because the factory cost, including overheads, can only be arrived at by the factory in which the appliance is to be made.

Technical design

The technical design department has a number of engineers and physicists, each specializing in a group of related products. For example, one member of the staff specializes in the technical design of all products involving the conversion of electrical energy to heat energy. Another specializes in all products involving the use of refrigeration. Another specializes in the design of electric motors and products involving a mechanism. Each of these members of the staff deals with the technical design of the group of products for which he is responsible. Each has available laboratory or workshop space in which he can conduct his own experiments and tests.

Mechanical design

The mechanical design department specializes in the mechanical design of products, it comprises an engineering drawing office and a prototype workshop. The engineering drawing office feeds the prototype workshop with sketches or drawings for prototypes. It can produce

Fig. 8.—Scorch test on radiant electric fire

Fig. 9.—Switch compartment of cooker undergoing temperature test

also finished working drawings for the manufacture of the final article, depending on the extent to which the factory concerned desires this to be done. The department is also responsible for keeping the centre up-to-date in regard to all new materials and finishes.

Appearance design

The appearance design department is manned by skilled industrial designers who create the appearance design of the products in the closest possible day to day association with the staff concerned with all the other functions. This department is responsible for the visual appearance of the products, and is concerned with such factors as form, colour, fashion, style, etc. It is, in principle, the bridge between technical development and the customer. The appearance of the boxes or other package in which the finished article is presented to the customer is also the responsibility of this department.

Planning engineering

The planning engineering section maintains the essential liaison between the design centre and the different factories producing the various articles handled by the design centre. It is responsible for giving day-to-day advice to the other members of the centre staff regarding tooling and the best utilization of existing plant. Where necessary, it prepares factory layouts involving the use of new plant or the re-siting of existing plant, and draws up all the necessary information required before it is possible to make an application to the board for capital expenditure. It prepares estimates for tooling as well as for plant and machinery so that, as a design is completed, figures can be available for the cost of tooling it up, and for the cost of any additional plant or machinery which may be required to make it.

It is a well-known maxim that people support most that which they help to create. The whole spirit of the design centre, therefore, is that it should be the servant of the various factories and not attempt in any way to be their master. The idea is simply that the factories concerned sub-contract their design work to this design centre. Consequently, the management of the different factories are encouraged to visit the centre as often as they wish in order to keep themselves thoroughly familiar and satisfied with the progress which is being made on their appliances. As a corollary to this the centre is able to act as a clearing house to ensure that maximum use is made of facilities in different factories helping each other out.

Suggestions for new appliances

The suggestion that a new appliance should be developed may come from any one of a number of directions. At the outset any suggestion is discussed with the sales department, and only sufficient preliminary work is done by the cost and information section to prepare a case for or against proceeding with the idea. Assuming that this information provides a case for proceeding, a meeting is held of all design centre personnel likely to be involved, together with the sales department concerned, and the works who will make the appliance. The object of this meeting is to prepare a brief as complete and comprehensive as possible to which the design centre may work.

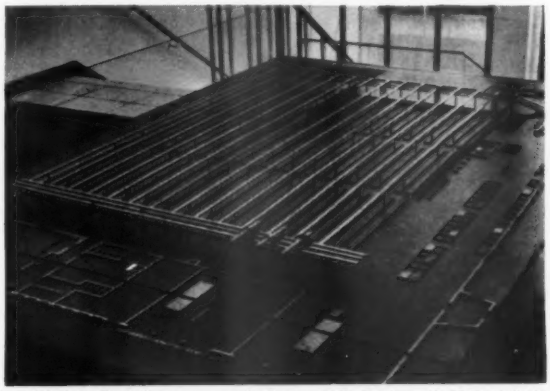
Working to this brief, the design centre proceeds in two stages, A and B. In the A stage the technical designers proceed to develop any new ideas which they may have or which may appear to be necessary. Any models which are constructed at this stage are constructed only to try out new ideas. They may be made up in any suitable way and bear no resemblance whatever to the final article. Generally speaking, the appearance design department is not concerned at this stage. However, the appearance designers are made aware at the outset of what is going on so that, while the technicians are working on the A stage, they can already be evolving their ideas.

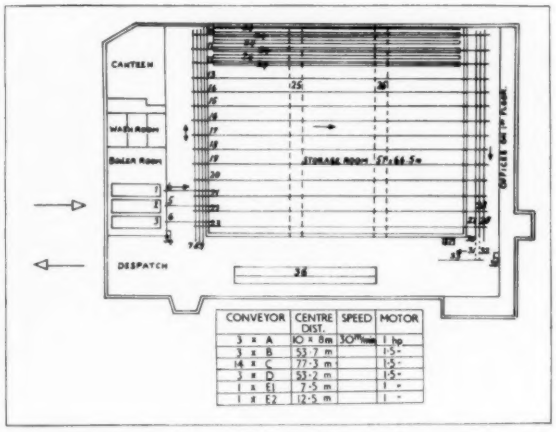
At the B stage the technical designers, with the collaboration of the mechanical drawing office and the workshop, proceed to construct working prototypes which are as complete as possible in the technical sense. That is to say, the article constructed has to perform the functions required; it has to be made in the way which

will be adopted ultimately although the various parts at this stage are, of course, largely made by hand since the tools have not yet been created. No money is wasted in attempting to incorporate the actual appearance which the final model will have in the B stage working prototypes. In parallel with these prototypes, however, the appearance designers, again with the co-operation of the workshop, design and make appearance prototypes. These models may contain no working parts at all, and may be made of materials entirely different from those proposed. In all probability, for example, they will be very largely made of wood. It is, however, important that these appearance prototypes should be finished so carefully that when seen they resemble exactly the final product, not only in shape but also in finish.

At the conclusion of the B stage, final agreement is reached with the works concerned regarding the whole design. The B stage appearance prototype is then submitted by the design centre on behalf of the works to the sales department for approval.

To reach agreement with the sales organization it may, of course, be necessary to make modifications to the prototype. In that event, works agreement is again sought before the modified prototype is re-submitted. The design centre can then hand the whole job over to the works concerned so that it can be tooled up for manufacture. The liaison between the design centre and the works is such as to enable the works to quote a price very soon after the conclusion of the B stage thus allowing a production order to be placed.





A model of the Sandvik conveyors at the factory of De Producent in Holland. Right, Scheme of the Sandvik conveyor system. 1–3, weighing bridges; 4–6, A, conveyors; 7–9, B, conveyors; 10–23, C, conveyors; 24, racks; 25–26, cross passages; 27–29, D, conveyors; 30, E1, conveyor; 31–32, roller ways; 33, E2, conveyor; 34, central post incoming cheese; 35, central post outgoing cheese; 36, racks for pallets; 37, washing machine

Warehouse Mechanical Handling

An extensive scheme in a new Dutch warehouse requires very little manpower and has high collecting and delivery rates

THE makers of Dutch Gouda cheese, De Producent, have experienced difficulties with the handling problems involved with their increasing turnover and the limited storage space available. Before the war they handled annually 11 million pounds, but by 1956 this figure had risen to 35 million pounds. They now handle an average of 350 tons per week.

To cope with the new circumstances a new warehouse has been built to suit the following requirements:

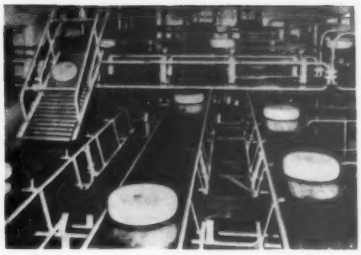
1. A high handling capacity in order to reduce the waiting time for lorries at both the incoming and despatch departments.
2. The minimum of handling.
3. Hygenic methods of handling.
4. Good supervision of workers.
5. The building should be treated as a transit warehouse, as the storage and maturing time is approximately 5–7 weeks.
6. A capacity of 4 million pounds mainly for the Gouda flat type cheese, with a small quantity of Edam and bread shaped cheese.

Also, under a more general heading, were air conditioning, and packing.

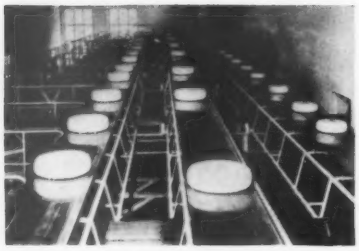
These points led to the idea of a single storey building with one way traffic of the product and a transport system by belt conveyors which brings the cheese to any point in the store room at a constant speed with the same number of people employed all the time.

For the purpose of handling the cheese in the warehouse a system of twenty-five Sandvik Steel band conveyors were designed and installed by Sandvik Steel N.V. Rotterdam, an associate of Sandvikens Jernverks Aktiebolag, Sweden. The new warehouse has only one floor, with double racks running along the length of the building, reaching from floor to ceiling, giving a total shelf length of 43 miles. Through every second double rack runs a conveyor at a height of about 8 ft. The actual storage area is 200 ft × 160 ft, and the whole building is 315 ft × 200 ft.

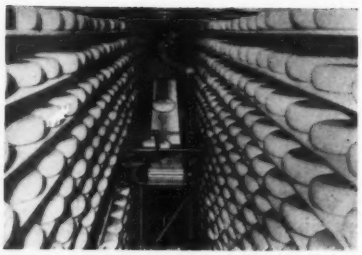
Lorries from the dairies, each carrying about 15 tons of cheese, enter the building and are driven on to one of three weigh bridges. In order to reduce waiting time for the lorries, it was necessary to have a very high handling capacity because the delivery of cheese takes place



Three A-conveyors unloading on to three B-conveyors



The carriage for discharging or loading cheese on to the storage shelves



Three of the B-conveyors discharging to three of the 14 C-conveyors

each day over a limited period of 4–5 hr.

The cheese is unloaded by hand and placed on one of the A-conveyors. It is transferred to any one of the B-conveyors by means of a travelling plough, and is then in turn transferred to any one of the C-conveyors which run through the double racks. The cheese is then ploughed off the C-conveyor on to a carriage running down each passage-way where the cheese is elevated or lowered to the required height for stacking, by means of a short rubber-belt conveyor. Apart from the lorry driver, only two men are needed per line for incoming traffic, one man to handle the cheese from the lorry to the first conveyor, the other man stands on the discharge mechanism and places the cheese in the racks. The three sets of incoming conveyors (A, B and C) can be controlled from a point near the weigh bridges.

When cheese is to be taken out of storage, the small carriage is loaded by hand from the racks and the cheese is loaded on to conveyors C. From there it is transferred to any of the conveyors D and finally discharged via conveyor E to the wrapping and despatch section. A similar labour force of two men only is needed for this operation. Conveyors C, D and E can be controlled from a point near the despatch section and telephone communication between the two control points enables the system to be used to the utmost efficiency. After wrapping, the cheese is loaded on pallets for future transportation by lorry.

Using this system, De Producent have obtained an incoming or outgoing capacity of 45 ton per hr. The system of 25 conveyors has a total conveying length of 4500 ft, and all conveyor bands are 18 in. × 0·032 in. running at 90 ft/min. Sandvik conveyors are manufactured in England by Sandvik Steel Band Conveyors Limited, Selly Oak, Birmingham.

Trade Mark Etching by Stencil

A method of reproducing trade marks, identification numbers, etc., on tools, machinery and metal goods of all kinds has been developed by Ellams Duplicator Company Limited, 5, Dean Street, London, W1. The process involves the use of a duplicator stencil which is used in connection with an electro-chemical etching machine.

When the stencil (which is non-conducting and resists the electrolyte) is placed in contact with a metallic surface, words, figures, and designs can be imprinted on the metal surface and providing that a black-and-white original can be supplied, the design will be reproduced faithfully in every detail on the stencil by means of an electronic stencil cutter. A source of light scans the original black and white design, and by using a photo-electric cell electrical impulses are generated causing the stencil to be perforated in the areas corresponding to the black portions of the original design.

Mechanical Lubricator for Automatics

A lubricator which is to be known as the Distributor pump and incorporates the Tecalemit capillary system, has been designed, in the first instance, to meet the lubrication requirements of single-spindle automatic lathes. The pump is supplied with up to 28 capillary outlet fittings mounted over a common oil reservoir and the pumping unit incorporated is suitable for rotary drive. The capillary outlet fittings are connected to the lubrication points on the machine through $\frac{1}{8}$ in. dia pipelines. The use of capillary fittings ensures that each individual point receives the precise amount of oil required, the hazards of starvation or over-lubrication being completely obviated.

A total output of up to 0·5 cc is achieved by each stroke of the pumping unit and the lubricator reservoir has a capacity of 4 pt.

Tecalemit distributor pump

The Distributor pump made by Tecalemit Limited, Plymouth, Devon is available with 28 capillary-outlet fittings at £35 net.

PORTABLE JIG-SAW.—The cutting tool illustrated above is a new addition to the Lesto range of electric tools manufactured in Switzerland. Weighing only 5 lb. the G.E.B. 14 is lighter and more powerful than the G.E.B. 11, which it supersedes.

The new model will cut up to $\frac{1}{16}$ in. mild steel, and up to 2 in. wood, formica, reinforced fibre glass, and many other materials. Various blades of different pitch are available to suit the grade of material to be cut. The machine works at 2,900 strokes per min and takes 200 W and is available in voltages between 50v and 250v a.c./d.c. The distributors are Trend Industrial Equipment Limited, 5, The Ridgeway, Stanmore, Middx.

Avoiding Embrittled Springs

Very high tensile steels are particularly susceptible to embrittlement by hydrogen absorbed during many cleaning and finishing operations. Several recent developments however, notably a vacuum plating technique for cadmium, greatly reduce the otherwise serious risks involved

By D. J. FISHLOCK

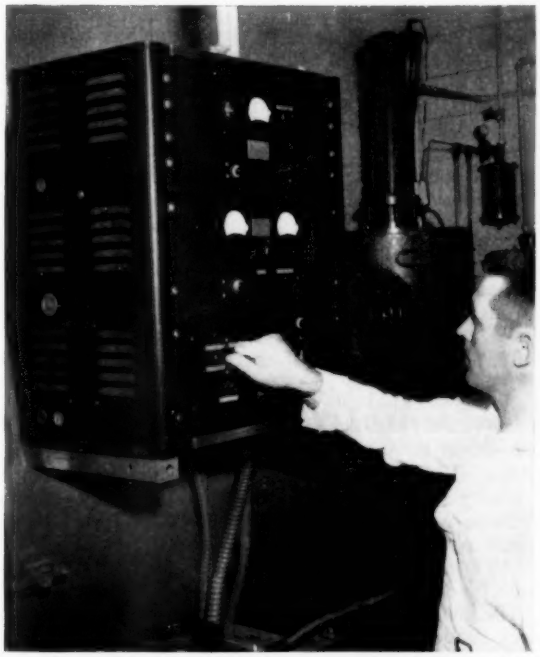
A FEW years ago an English motor-bus company was sorely embarrassed to find its entire fleet of new vehicles rendered unserviceable in rapid succession. The fault—a cracked brake-spring, the same in each: the trouble—hydrogen embrittlement. Many such instances can be cited, including the failure of a high-tensile steel bolt which was held responsible for the crash of a Viscount air-liner recently. Hydrogen absorption by metals, particularly steels, has been a metal-working problem since it was first recognized ninety years ago. Two salient ways of introducing the gas, faulty welding techniques and pick-up by the molten metal, have received much attention; the third, however, the absorption of nascent hydrogen at room temperature, is none the less of great significance.

The cold embrittlement of steels remains an inadequately explained and rather unpredictable phenomenon. It is known that the susceptibility of cold-worked carbon steel increases with the carbon content and is considerable above 0·6% C while trouble has arisen with low carbon sheet and wire due to failure to remove the oil lubricant. This oil will carbonize during annealing and may carburize the skin of the metal and render it susceptible to embrittlement.

Even more sensitive are high tensile steels in the hardened and tempered condition. Thus, the spring steels are particularly subject to embrittlement. It is now recognized that when hydrogen is released in nascent form at the metal surface the very active atoms diffuse rapidly through the crystal lattice. At room temperature, however, the tendency for it to combine with or dissolve in the alloy is negligible and it therefore accumulates in discontinuities such as blow holes or contraction cavities. Here it combines to the molecular form H_2 which cannot diffuse readily through the lattice, and since the nascent gas continues to accumulate enormous pressures are generated, aggravated further by the high heat of reaction of the combination.

This embrittlement arises in practice through the release of the gas by chemical or electrolytic reactions during pickling, cleaning, electroplating, etc., and greatly complicates the surface preparation and finishing of springs. Acid pickling has been found especially disastrous, as in the above instance where the springs had been acid dipped for tarnish-removal. Shock-loading may well cause the pickled springs to shatter, and display the characteristic crystalline fractures of brittle metal; if pickled under stress they often crack during the process.

The embrittlement is usually temporary however, induced by the enormous internal pressures, and unless the elastic limit of the metal has been exceeded, and the lattice has fissured, the embrittlement will gradually disappear. A fissured lattice, of course, cannot be rectified by any means short of remelting. The restoration of ductility, which may require weeks or months at room temperature, can be greatly accelerated by a low temperature heat-treatment and an hour at 200° C, is usually adequate; sometimes as long as 36 hr at this temperature have proved necessary, though. Inexplicably, immersion in boiling water dispels the gas more rapidly than stoving in dry air, and this proves convenient in practice.



Anadite Inc. U.S.A.

Vacuum coating apparatus whereby high tensile steels can be plated with 0·0005 in. or more of cadmium by evaporation. The metal is first sand-blasted to provide a 'key'

It is strongly advisable to avoid acid treatment for susceptible materials whenever possible, but certain precautionary measures minimize the incidence of failure. Most valuable is the use of an oxidizing pickle such as nitric acid, or of a sulphuric acid solution containing 2% to 5% of an oxidizing agent such as sodium dichromate or chromic acid. This should be as cool and dilute as production efficiency will permit; if by careful heat-treatment the scaling can be minimized, and a 2% or 3% acid solution is used, embrittlement is often entirely avoided. Again, inhibitors tend to increase the occlusion of hydrogen and should be avoided. Similarly, certain elements derived from impure acid or from alloy steels promote embrittlement; these include lead,

selenium, sulphur, arsenic and antimony. The pickle should therefore be discarded frequently, and not used for alloys such as free-cutting steels. Anodic pickling in sulphuric acid, providing that the etching is minimized, is a safe method of removing quite thick scales and rust deposits: cathodic pickling, however, especially in cyanide or hydrochloric acid, is decidedly hazardous, and the same applies to cathodic alkaline degreasing. An interesting descaling technique for high carbon wire destined for valve-springs has been described. This consisted of electro-machining the scale away anodically in an acid solution. In this way scale, decarburized skin and surface defects were removed to a uniform depth, leaving a smooth finish with no possibility of embrittlement.

The problem of finishing the springs is more complex, though. Electroplating is probably the most generally satisfactory method of protecting metals, but the application of a thin, relatively impermeable deposit of zinc or cadmium, for instance, effectively seals in any hydrogen occluded during the pretreatment and inhibits its release during the subsequent heat-treatment; alternatively, released gas will cause the plating to blister or become very porous. This difficulty can often be avoided by using a non-embrittling pickle or a mechanical descaling process such as vapour-honing or shot-blasting. Vapour-honing has proved exceptionally successful, especially in its latest forms such as capri-honing which greatly speeds the action, but shot-blasting tends to roughen the metal unduly. This may, by itself, tend to weaken and lower the ductility of the spring, and it is often found that a higher plating voltage is necessary to initiate deposition on such surfaces. This releases excessive amounts of hydrogen which again may promote embrittlement.

Of the usual electroplating solutions, chromium undoubtedly induces the greatest embrittlement, followed in descending order by cyanide zinc, copper and cadmium, and then by acid zinc, copper and nickel solutions. Cyanide certainly appears to promote embrittlement to some extent, but it is not practicable to use an acid zinc solution directly on steel while no acid cadmium solution has been available until recently. There have, however, been attempts to develop a non-cyanide cadmium solution to eliminate embrittlement risks with highly stressed components. It has been found that the more strongly acidic or alkaline a plating solution was, the greater the tendency for embrittlement, and complex amino-acid solutions with a pH near 7 were thus evolved; a fluoborate cadmium solution has also been found to induce much less, if any, embrittlement. Experimental indications are that the embrittlement induced is markedly less than in cyanide plating.

Another recent process for cadmium plating high tensile steel is vacuum coating, in which a deposit of pure cadmium up to 0·0005 in. and more in depth, and conforming to specification requirements for adhesion, uniformity and corrosion resistance, can be built up by continuous evaporation with no possibility of embrittlement during plating. It has also been claimed that a preliminary deposit of Kanigen nickel/phosphorus alloy before cadmium electroplating prevents the absorption of hydrogen.

Horizontal Type Bandsaw Cuts 10 in. Dia Bar

A new type of machine designated '09' has recently been added to the Limitax range of bandsawing machines made by The New Fortuna Machine Company Limited, Fortuna Works, Southmead, Westbury-on-Trym, Bristol. It has capacity for cutting round bars 10 in. dia, squares up to 8 in. and flats or sections 5×15 in., using a 1 in. wide blade 12 ft long.

The machine is heavily built and extensive use has been made of fabricated construction in conjunction with stout iron castings. It is mounted on a steel fabricated base, which incorporates a coolant tray and separate motor-driven suds pump. An independent cut-out switch for the pump is incorporated.

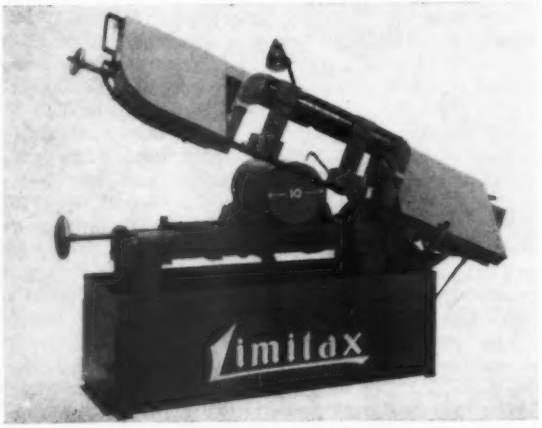
A universal vice is arranged to swivel at angles up to 45°; the capacity at 45° is 9 in. dia round bars.

Castings bolted to a steel channel section form the bandsaw frame which is pivoted on a support fixed to rear end of bed, and is further strengthened by an auxiliary frame mounted vertically, in the throat of the main frame. This frame carries the bandsaw guide holders which, fitted with wipers to remove swarf, serve to give the blade a quarter twist, and so bring it into the vertical position for cutting. The actual guide rollers are carried on ball bearings, and are adjustable to bring the horizontal rollers close on to the blade.

The saw frame descent is controlled by an oil dashpot, which is fitted with a pressure gauge to enable dashpot adjustment to be made to suit material being cut. A quick-release control fitted and operated from the front of the machine enables the saw blade to be brought quickly down on to the work. The bandsaw driving wheel is driven by a 16 hp motor mounted on one of the frame supports and carried on a screw adjustable platform. This device enables two speeds of 125 or 55 fpm to be obtained by simply slipping the V-velts over the steps of the pulley. The machine is thoroughly guarded but the belts and saw blade are accessible by means of hinged covers.

To prevent overloading of saw blade a special tensioning arrangement is fitted to the idler wheel slide, and arranged to be independent of variations in blade lengths. The position of the idler wheel may also be adjusted for band saw alignment purposes.

The machine occupies a floor space of 96 × 33 in., has a height of 65 in. with saw frame raised, and weighs 12 cwt.



Type 09 Limitax horizontal bandsawing machine cuts 10 in. bar at 125 or 55 fpm

Steam Plant for Nuclear Power Stations

Continuing the comparison of principal design data on nuclear power stations in Great Britain commenced in our last issue.

By J. R. FINNIECOME, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F., Consulting Engineer
(Technical Adviser and Design Consultant to the U.K.A.E.A. 1950–1956)

6. Comments on the dual pressure steam cycle

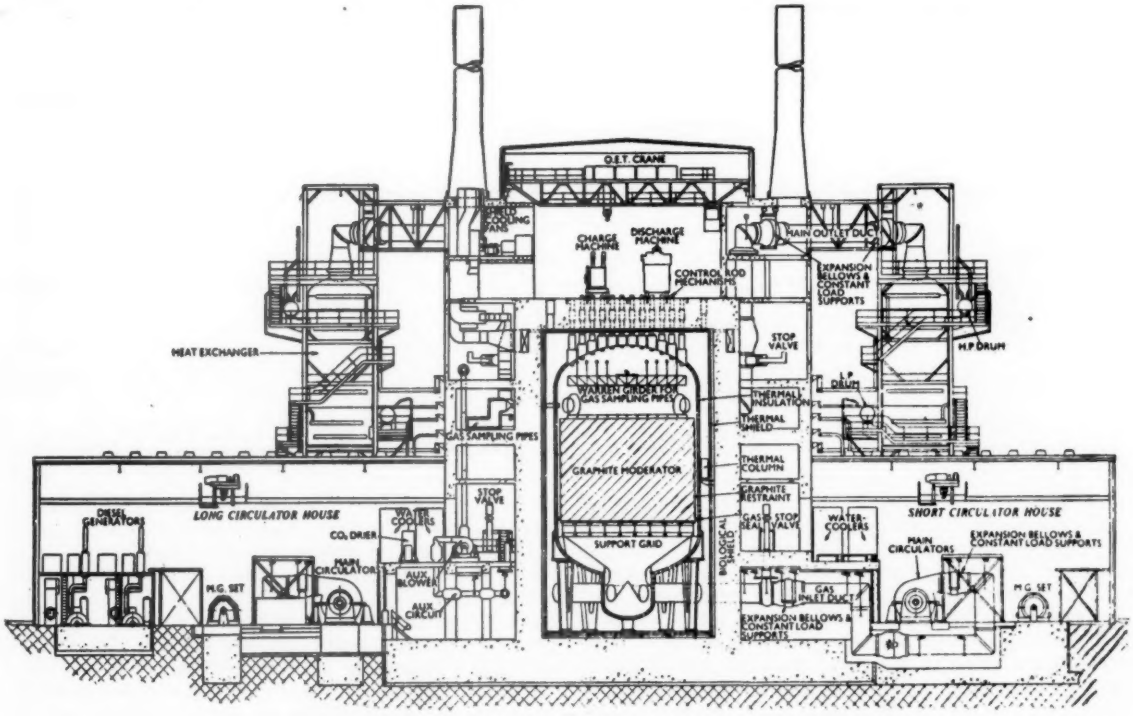
Before proceeding to a summary of the design data of the heat exchangers for the nuclear power stations in Britain it seems logical to direct attention to the steam cycle of such a plant, having graphite-moderated and gas-cooled reactors. In 1948 Messrs. Babcock & Wilcox were specially requested, and therefore, highly privileged, to make an intensive study of suitable steam cycles for nuclear power stations. One must pay tribute to W. R. Wootton for he was primarily responsible for this exhaustive investigation. As a result of his comprehensive analysis of both the single and dual-pressure steam cycles it was possible to recommend the latter, for it gave a higher overall station efficiency. Consequently, the dual-pressure system was not only applied to Calder Hall but to all the other nuclear power stations.

It is instructive to present the overall station efficiency in relation to the reactor inlet gas temperature for both the single and dual-pressure steam cycles as indicated in Fig. 1. These two graphs have been plotted from values scaled from Fig. 7, on page 503 of *Engineering* for October 19, 1956. The scaled values are tabulated below:

Reactor inlet gas temperature	Overall station efficiency		
	single pressure cycle	dual pressure cycle	difference relative to the single pressure
°F	%	%	%
250	17·17	20·85	21·43
300	19·85	22·69	14·31
350	21,46	22·84	6·43
400	21·45	21·84	1·82
450	20·00	20·31	1·55

The optimum values are:
single-pressure 21·7% at 377°F
dual-pressure 23·0% at 330°F

It is interesting to plot the difference in the overall station efficiencies between the single and the dual-pressure steam cycles as a percentage of the former, as shown in Fig. 2, which indicates the improvement as a function of the reactor inlet gas temperatures. On the basis of Fig. 2 one obtains for Calder Hall, Bradwell and



Calder Hall nuclear power station. A section through the reactor building and circulator houses

Hunterston the following improvements in the overall station efficiency when using the dual-pressure steam cycle at reactor inlet gas temperatures of 284° F, 358° F, and 400° F respectively.

Station	Reactor inlet gas temperature	Improvement in overall station efficiency
	°F	%
Calder Hall	284	16·9
Bradwell	358	5·2
Hunterston	400	1·8

Examination of Figs. 1 and 2 and the above table reveals that the dual-pressure steam cycle gives an improvement in the overall station efficiency of 16·9% for Calder Hall, 5·2% for Bradwell and only 1·8% for Hunterston.

As the improvement in the thermal performance is relatively small at reactor inlet gas temperatures of

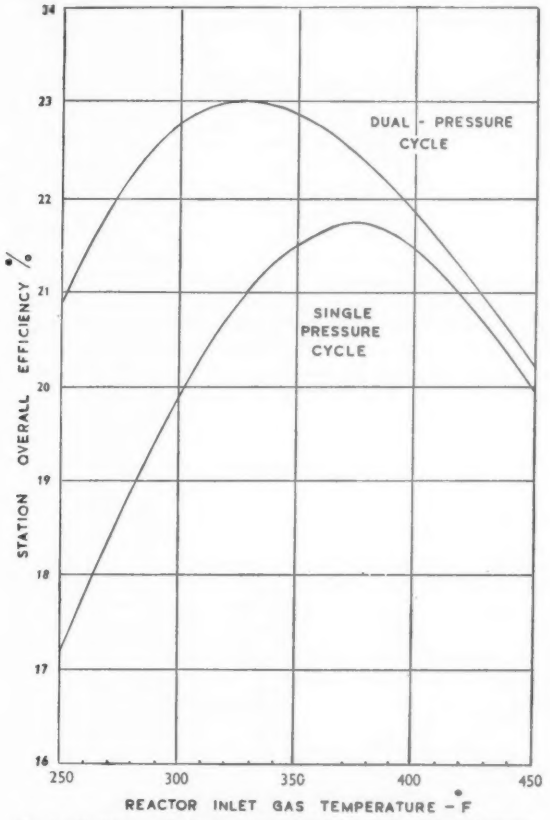


Fig. 1.—Station overall efficiency for gas cooled graphite moderated reactor

400° F and above, it might prove advantageous financially to use the simple single-pressure instead of the more complex dual-pressure steam cycle, for it is of utmost importance to examine with special care the additional capital expenditures involved in order to achieve this thermal gain. A final recommendation is to explore with great thoroughness both these steam cycles for each project from the point of view of total cost per unit sent out from the station. The minimum value is then the deciding factor for the selection of the most suitable steam cycle. Such a detailed analysis of the costs of various sections affected by these two steam cycles, should prove not only instructive but most profitable.

In the dual-pressure steam cycle both the high and low pressure steam are generated in the heat exchanger. The quantity of high pressure steam as a percentage of the total high pressure and low pressure steam produced is, for instance, 76·96% for Calder Hall, 67·26% for Hunterston and 66·67% for Hinkley Point, therefore, approximately 2/3 for the larger nuclear power stations. An advantage of the dual-pressure steam cycle is that with it higher pressures can be obtained than with the single-pressure system.

The steam pressure that can be produced in the heat exchanger depends primarily on the feed temperature and especially on the temperature difference between the gas coolant and the water at outlet of the coolant from the evaporation section of the heat exchanger. Referring to the basic principles of heat transfer, the highest steam pressure occurs at the economic minimum temperature difference and at the lowest feed temperature.

7. Performance of heat exchangers

Typical temperature–heat diagrams for the single- and the dual-pressure steam cycles for a heat exchanger are shown in Figs. 3 and 4 respectively. The actual performance values for Calder Hall are indicated for the dual-

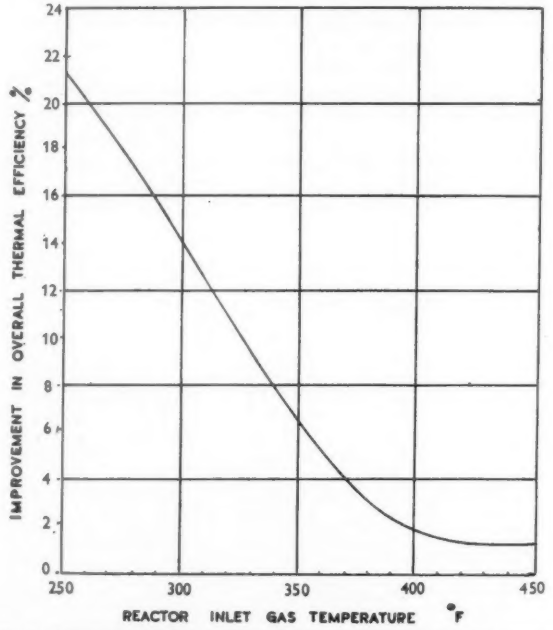


Fig. 2.—Improvement in station overall thermal efficiency with the dual pressure relative to the single pressure steam cycle

pressure cycle in Fig. 5. These show clearly the temperature gradient of the gas coolant and the temperatures of the high pressure and low pressure steam in relation to the heat generated in the various sections of the heat exchanger, such as the economizers, the evaporators and the superheaters. The horizontal scale of Figs. 3, 4 and 5 can be either the heat content, the heat in megawatts (MW) or a percentage of total heat generated in the heat exchanger. On examining Fig. 5 for Calder Hall one finds that the difference of the temperatures of the gas coolant and the water or the high pressure and low

pressure steam are as follows:

		Gas temperature	Water or steam temperature	Difference in temperatures
		°F	°F	°F
(a)	L.T. economizer inlet	275	100	175
(b)	L.T. economizer outlet	338	326	12
(c)	L.P. steam outlet	396	365	31
(d)	H.T. economizer outlet	421	390	31
(e)	H.P. steam outlet	637	591	46

This table is of particular interest from the point of view of design for one finds that the difference in the temperature is:

(a) 12° F at the low temperature economizer outlet.
(b) 31° F at the low pressure steam outlet and also at the high temperature economizer outlet.
(c) 46° F at the high pressure steam outlet.

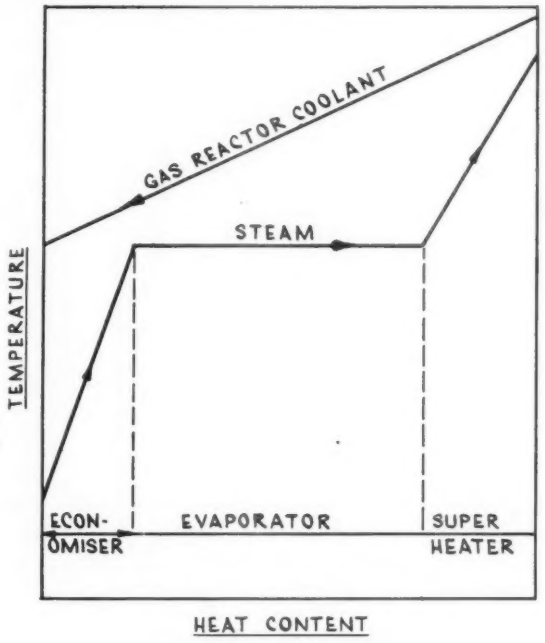


Fig. 3.—Single pressure system

These temperature differences can be regarded as fairly reasonable for the economic heat transfer in heat exchangers, using a gas as the coolant.

8. Pressures and temperatures at the outlet from the heat exchanger and at the turbine stop valves

Detailed information is contained in Table VIII. It has been prepared to indicate the pressure and temperature drops between the outlet from the heat exchanger and the inlet to the turbine stop valves. This table reveals:

(a) H.P. steam pressure drop of 25 psi
(b) H.P. steam temperature drop of 4° to 10° F, the average being about 5° F.
(c) L.P. steam pressure drop of 10 to 20 psi with an average of 15 psi
(d) L.P. steam temperature drop of 4° to 15° F. The average value is about 10° F.

9. Particulars relating to the heat exchangers

The designed heat ratings, the temperatures, the pressures, the steam flows, the dimensions and the weights are summarized in Table IX. One finds that the largest heat exchanger has a diameter of 21 ft 6 in., a height of 90 ft, a shell thickness of $2\frac{3}{8}$ in. and weighs 1350 ton.

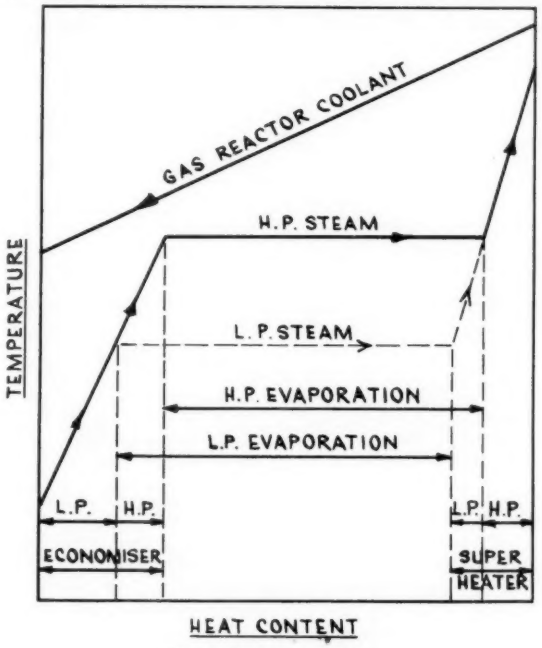


Fig. 4.—Dual pressure system

There are twelve such heat exchangers for Hinkley Point. The heat rating of each is 160 MW(H).

10. Steam turbines for nuclear power stations

All nuclear power stations in operation and under construction in Britain have firstly graphite moderated and gas-cooled reactors and secondly main turbines

Table VIII.—PRESSURES AND TEMPERATURES AT THE HEAT EXCHANGER AND AT THE TURBINE STOP VALVE

1	2	3	4	5	6	7	8
Item	Nuclear power station	Unit	Calder Hall A and B	Berkeley Gloucester	Bradwell Essex	Hunterston Ayrshire	Hinkley Point Somerset
1	H.P. steam pressure at heat exchanger outlet	psig	210	305·3	755	585	640
2	H.P. steam pressure at the turbine stop valve...	psig	185	295·3	730	560	615
3	Pressure drop (1)—(2)	psig	25	10	25	25	25
4	H.P. steam temperature at the heat exchanger outlet	°F	595	612	704	700	685
5	H.P. steam temperature at turbine stop valve	°F	590	604	700	690	680
6	H.P. temperature drop (4)—(5)	°F	5	8	4	10	5
7	L.P. steam pressure at the heat exchanger outlet	psig	48	62·3	195	155	170
8	L.P. steam pressure at turbine stop valve ...	psig	38	49·3	180·3	140	150
9	L.P. pressure drop (7)—(8)	psi	10	13	14·7	15	20
10	L.P. steam temperature at the heat exchanger outlet	°F	350	612	704	670	670
11	L.P. steam temperature at the turbine stop valve	°F	340	596	700	660	655
12	L.P. steam temperature drop (10)—(11) ...	°F	10	16	4	10	15

operating on the dual-pressure steam cycle, which was adopted to enable the desired optimum net overall thermal efficiency to be obtained from the station.

In large conventional stations, using either coal or oil as fuel, the steam turbines which operate on the single-pressure steam cycle are now standardized as far as the ratings and the operating conditions are concerned. By contrast, the specific requirements for steam turbines for nuclear power stations are entirely novel. In addition the operating pressures and temperatures at the turbine stop valves are considerably lower, consequently the manufacturers of the turbines were faced with the problem of preparing entirely new designs. This necessitated directing special attention and much original thought to the development of a new series of turbines. Furthermore, it was important to give careful consideration to the design of the governing and control gear from the point of view of reliability of operation on both high and

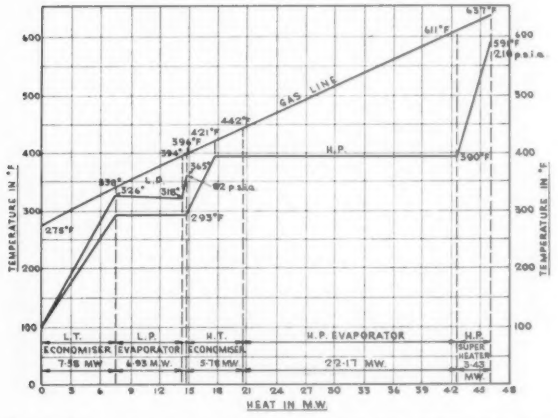


Fig. 5.—Heat exchanger temperature—heat diagram dual pressure steam cycle for full load conditions

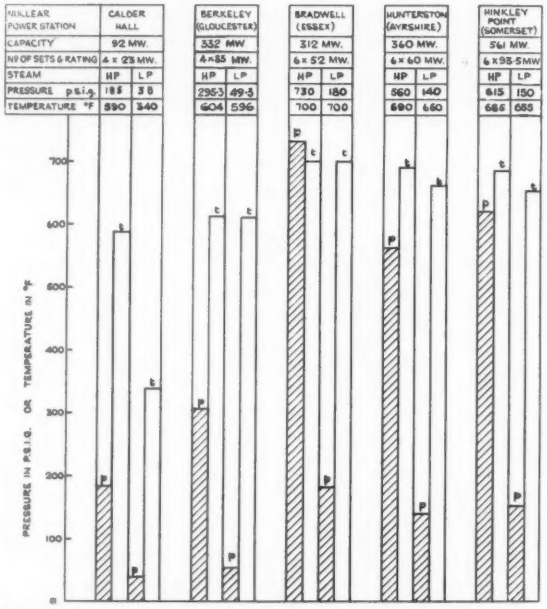


Fig. 6.—H.P. and L.P. steam conditions at the turbine stop valves of five nuclear power stations

low pressure steam. The principal reason for the low steam conditions at the turbine stop valves is the present optimum limit for the permissible temperature of the reactor fuel can of 800° F for Magnox A12.

The combination of the dual-pressure steam cycle, the remarkably low pressures and temperatures at the H.P. and L.P. stop valves and the minimum feed heating has the undesirable disadvantage of increasing, for a specified rating, the total quantity of steam, but particularly the total volume through the turbine. Consequently, such turbines are considerably larger, especially at the L.P. and the exhaust end, than those installed in conventional steam stations operating at the standard optimum conditions and specified for well-established ratings.

The adiabatic heat drop from the stop valve to the turbine exhaust is decreased with the lower steam conditions; therefore, to obtain an additional improvement in the turbine efficiency it is essential to reduce proportionally the combined leaving and exhaust losses to a reasonable economic value by enlarging the leaving and the exhaust areas. Unfortunately, this special requirement increases considerably the size of the low pressure turbine and therefore adds to the cost of the set.

10.1. Steam conditions at the turbine stop valves

These are presented for the five nuclear power stations in Fig. 6, which indicates the pressures and temperatures for both H.P. and L.P. steam. It will be observed from this that since Calder Hall, operating on H.P. at 185 psig and 590° F L.P. at 38 psig and 340° F, the steam conditions have increased considerably to a maximum of

Table IX.—DESIGN PARTICULARS OF THE HEAT EXCHANGERS

1	2	3	4	5	6	7	8
Item	Nuclear power station	Unit	Calder Hall A and B	Berkeley Gloucester	Bradwell Essex	Hunterston Ayrshire	Hinkley Point Somerset
1	Heat rating of each reactor	MW(H)	180	550	530	530	986
2	Number of heat exchangers per reactor		4	8	6	8	6
3	Inlet gas temperature at heat exchanger	°F	637	660	732	745	702
4	Outlet gas temperature at heat exchanger	°F	275	318	354	392	350
5	Drop in gas temperature in heat exchanger	°F	362	342	378	353	352
6	H.P. steam per heat exchanger	lb/hr	99000	—	—	143100	305556
7	H.P. steam pressure at heat exchanger outlet	psig	210	—	755	585	640
8	H.P. steam temperature at heat exchanger	°F	595	612	704	700	685
9	L.P. steam flow per heat exchanger	lb/hr	29650	—	—	69500	152777
10	L.P. steam pressure at heat exchanger outlet	psig	48	—	195	155	170
11	L.P. steam temperature at heat exchanger	°F	550	—	704	670	670
12	Total H.P. and L.P. steam through heat exchanger	lb/hr	128650	—	—	212600	458333
13	Diameter of heat exchanger	ft in.	17 ft 3 in.	17 ft 6 in.	19 ft 0 in.	20 ft 0 in.	21 ft 6 in.
14	Height of heat exchanger	ft in.	77 ft 4 in.	70 ft 0 in.	87 ft 0 in.	80 ft 0 in.	90 ft 0 in.
15	Thickness of shell	in.	$1\frac{5}{16}$	$1\frac{1}{8}$	—	—	$2\frac{3}{8}$
16	Weight of each exchanger	ton	200	400	—	—	1350
17	Heat taken up by water and steam per heat exchanger	MW(H)	46·15	—	—	—	160

730 psig, 700° F for H.P. and 180 psig, 700° F at Bradwell. These latter values are based on a maximum fuel can temperature of 800° F. The present optimum steam conditions are still well below those applicable to conventional base load stations.

absolute temperature–entropy diagram as indicated for Calder Hall and Hunterston in Figs. 7 and 8, which contain tables summarizing the essential thermodynamic values. The H.P. and L.P. portions are shown shaded. The H.P. steam as a percentage of the total is 76·96% for

POINT	UNITS	1	F	2'	2	3	4	5	6
p	p.s.i.g	28·25"Hg	-	38	185	185	185	38	28·25"Hg
p	p.s.i.a.	0·857	0·950	52·7	199·7	199·7	199·7	52·7	0·857
ts or t	°F	96·6	100	284·2	381·7	381·7	590	340	96·6
T	°F	556·3	559·7	743·9	841·4	841·4	1049·7	799·6	556·3
h_s or H	BTHU/LB	64·6	68·02	253·6	355·4	1199·6	1316·3	1204·7	-
ϕ_s or ϕ	BTHU/LB/°F	0·1231	0·1295	0·04156	0·5438	1·5468	1·6497	1·6919	1·6919

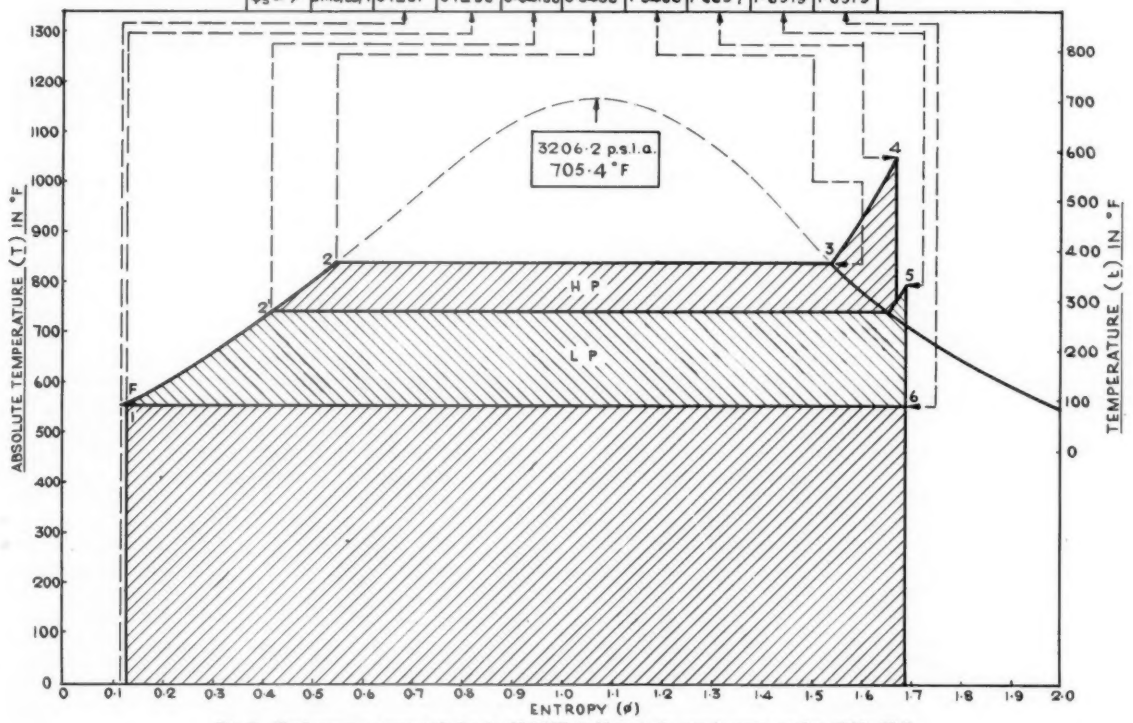


Fig. 7.—Dual pressure steam cycle for the 23 M.W. turbines at the atomic power station, Calder Hall

10.2. Presentation of the dual-pressure steam cycle

In view of its importance it is specially instructive to demonstrate the dual-pressure steam cycle in the

Calder Hall and 67·26% for Hunterston. The net thermal efficiencies of these stations are 21·5% and 28·8% respectively.

Table X.—A SUMMARY OF THE ESSENTIAL PARTICULARS OF THE STEAM TURBINES

1	2	3	4	5	6	7	8
Item	Nuclear power station	Unit	Calder Hall A and B	Berkeley Gloucester	Bradwell Essex	Hunterston Ayrshire	Hinkley Point Somerset
1	Total generating capacity MCR	MW	92	332	389·5	360	660
2	Number of main turbines		4	4	6	6	6
3	Number of auxiliary turbines		—	—	3	—	3
4	M.C. rating of each main turbine 3000 rpm ...	MW	23	83	52+5%	60	93·5
5	M.C. rating of each auxiliary turbine 3000 rpm	MW	—	—	20·5	—	33
6	Number of shafts		1	1	1	1	1
7	Number of cylinders		2	2	2	2	3
8	Number of exhausts			3	2	3	4
9	H.P. steam pressure at T.St.V	psig	185	295·3	730	560	615
10	H.P. steam temperature at T.St.V ...	°F	590	604	700	690	680
11	H.P. steam. Quantity of steam at T.St.V ...	lb/hr	198000	—	—	382000	—
12	L.P. steam pressure at T.St.V	psig	38	49·3	180·3	140	150
13	L.P. steam temperature at T.St.V ...	°F	340	596	700	660	655
14	L.P. steam. Quantity of steam at T.St.V ...	lb/hr	59300	—	—	186000	—
15	Total steam	lb/hr	257300	—	—	568000	—
16	H.P. steam in % of total	%	76·96	—	—	67·26	66·67
17	L.P. steam in % of total	%	23·04	—	—	33·74	33·33
18	Vacuum at turbine exhaust 30 in Hg barometer	in Hg	28·25	29·1	—	28·9	29·0
19	Final feed temperature	°F	100·4	170	—	296	166
20	Wetness at turbine exhaust	%	11·0	—	—	12·5	—
21	Number of H.P. stages		22	6+2	—	7+7	—
22	Number of L.P. stages		2×6	2+3(4+11)	—	(3+1)+(3×6)	—

10.3. Summary of essential particulars of the steam turbines

Detailed information on the series of special turbines for the five nuclear power stations in Britain is recorded in Table X. The main characteristic features of these turbines are:

(a) The 93·5 MW turbines for Hinkley Point are the largest to be installed in a nuclear power station in this country. It has three cylinders and four exhausts designed for 29 in. Hg vacuum at 30 in. Hg barometer whilst:

(1) The 200 MW set at High Marnham, designed for 2350 psig, 1050° F, a reheat of 1000° F, 28·7 in. Hg, a final feed temperature of 460° F and 6-stage feed heating, has three cylinders and only a three-flow exhaust.

(2) The 275 MW for Blyth-B, designed for 2300 psig, 1050° F, a reheat of 1050° F, 29 in. Hg, a final feed temperature of 486° F and 7-stage feed heating has three cylinders and four exhausts.

(b) The 83 MW for Berkeley is a three cylinder turbine with three exhausts, whilst the 120 MW for Drakelow-B with operating condition of 1500 psig, 1000° F, a reheat of 1000° F, 28·7 in. Hg, a final feed temperature of 436° F and 6-stage feed heating has three cylinders and a two flow exhaust.

POINT	UNITS	1	F	2'	2	3	4	5	6
p	p.s.i.g	28·9 lb/in²	0	140	560	560	560	140	28·9 lb/in²
p	p.s.i.a.	0·539	63·08	154·7	574·7	574·7	574·7	157·7	0·539
t_s or t	°F	81·8	296	368·8	481·7	481·7	690	660	81·8
r	°F	541·4	755·6	820·4	941·3	94·3	1149·6	1119·6	541·4
h_s or H	BTHU/LB	49·9	265·6	533·1	466·4	1204·7	1346·0	1355·4	-
ϕ_s or ϕ	BTHU/LB/°F	0·0966	0·437	0·5171	0·6668	1450·2	1·5863	1·7344	1·7344

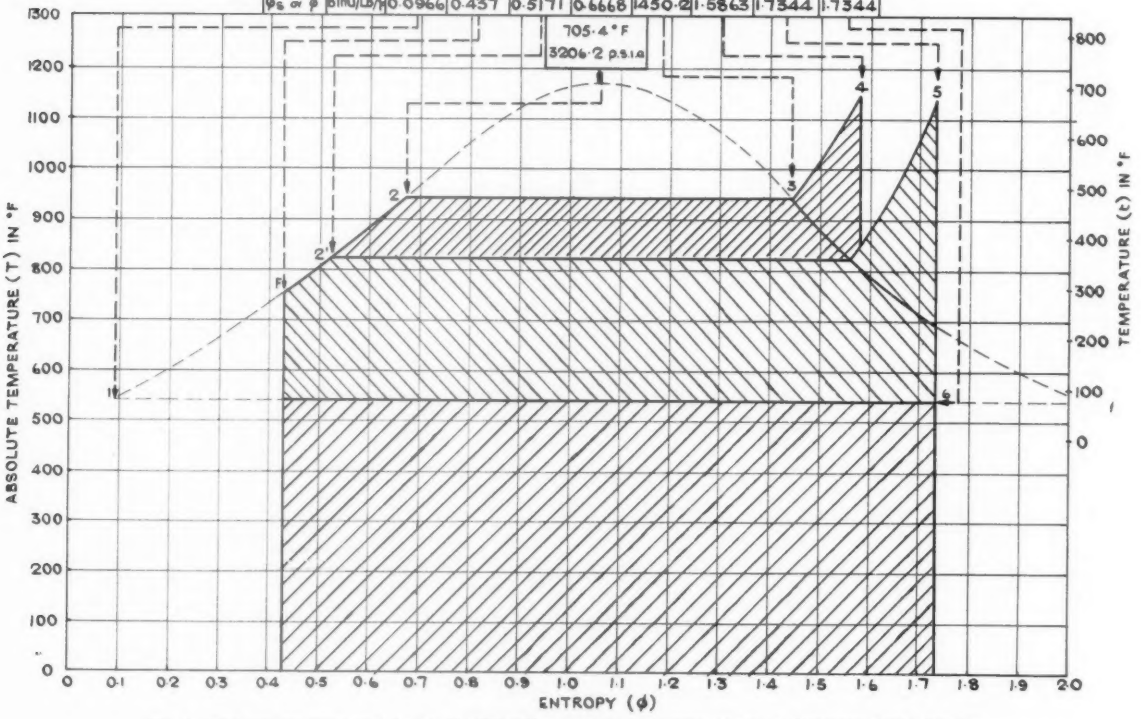


Fig. 8.—Dual pressure steam cycle for the 60 MW turbines at the nuclear power station at Hunterston, South Scotland

(c) The above comparisons indicate clearly that for the same rating the turbines for nuclear power stations is very much larger than those installed in conventional stations in this country.

(d) The 60 MW set at Hunterston has two cylinders, and three exhausts and has also the highest final feed temperature, i.e. 296° F. Consequently this station has the highest net thermal efficiency, namely 28·8%.

(e) The H.P. steam as a percentage of the total H.P. and L.P. is 76·96% for Calder Hall, 67·26% for Hunterston and 66·67% for Hinkley Point.

(f) The final feed temperatures are 100·4° F, 296° F and 166° F for Calder Hall, Hunterston and Hinkley Point respectively.

(g) The number of stages are indicated in items 21 and 22 in Table VI for both the H.P. and L.P. cylinders.

(h) The wetness at the turbine exhaust is 11·0% for Calder Hall and 12·5% for Hunterston.

Developments in the Tempering of Steel

Heat-treatment experiment and research continues to provide more accurate knowledge of the principles and effects of the various operations, including the tempering process which is one of the most important in heat-treating metals. In the following notes some of the more recent discoveries and advances are outlined.

Effect of silicon on tempering

IT has been known since 1953 that silicon has a marked influence on the tempering of carbon steels. It was discovered that tempering is kinetically divisible into three stages, and the influence of silicon upon each of these stages was known to exist, but was not ascertainable in detail because no method then existed of obtaining quantitative kinetic relationships for the three stages. Since then, a magnetic method has been developed and it is now possible to state with some accuracy what effect silicon has upon the kinetics of the tempering stages.

It appears to have been established that when silicon occurs in the composition of a carbon steel, it is essential that tempering temperatures should be increased by approximately 75° C because only in this way is the structural decomposition, brought about during the third stage of tempering, appreciably perceptible. These higher tempering temperatures are necessary, therefore, to ensure that both the second and third stages are completed. In the third stage an adequate silicon content controls the reaction by means of a diffusion of the element away from the interface, and in this instance silicon takes over the function otherwise exercised by carbon.

Silicon steels come to a state of metastable equilibrium somewhat slowly, and the reason is probably that the silicon atoms are only gradually transferred from the precipitated carbide to the matrix. It has also been suggested that both aluminium and phosphorus have a similar retarding effect on the third stage of tempering in carbon steels. The steels referred to are what is known as medium carbon steels of commercial type.

Tempering iron-carbon alloys

There is still a great deal of uncertainty regarding the tempering of iron carbon alloys as regards the phase transformations involved and the modifications of microstructure and mechanical properties arising therefrom. Efforts have therefore been made to obtain a more complete indication of these microstructural changes, and particularly of the changes in martensite consequent upon tempering. The alloys concerned in these investigations were iron-carbon alloys of high purity containing from 0·15% to 1·4% carbon, and a most useful tool of which full use was made was the electron microscope.

To give the results in a few lines would be impracticable, as they are highly technical and demand a competent knowledge of the more abstruse details of metallurgy; but if the following summary gives only a restricted account of what has been discovered, it may assist readers interested to follow up the subject by a study of the detailed researches. The maximum tempering temperature adopted for the experiments was 370° C.

In the first stage of tempering of these alloys, a network of a special form of carbide forms at martensitic subboundaries when the carbon content exceeds 0·25%. At the start of the third stage, this passes into solution and cementite is precipitated out both at the martensitic boundaries and within the martensite. It is now suggested that the formation of these cementite films may have some relation to an observed embrittlement of the alloys at tempering temperatures in the region of 120° C. If the tempering temperature exceeds 120° C, the embrittlement disappears by reason, it is believed, of a softening of the alloy owing to a lowering of the carbon content of the matrix.

Tempering and grain growth

The control of grain size in metals is rapidly becoming one of the most important factors in metallurgical practice. For this it is necessary to comprehend fully the mechanics of recrystallization and grain-growth, as only in this way is it possible to obtain the best working properties. As a result of previous investigations, it was shown that tempering is one of the forms of heat treatment obeying a rate-process theory, or in other words, there is a relation between time and temperature for a given hardness. Further researches into this theory have now been carried out, and the results show that for a specific metal an absolute rate of grain growth exist and seems to be governed by composition alone. If this fact is effectively used, it should, in further research, serve to minimize the number of tests necessary for the evaluation of recrystallization and grain growth behaviour.

High-temperature tempering

We have seen earlier that a close study of tempering in the range up to 370° C was made. Further studies have been made of tempering the iron-carbon alloys at temperatures *above* 370° C, when the carbon content exceeds 0·25%. In the earlier researches summarized above, it was shown that the first stage of tempering consists of the formation of a special carbide network. This stage ends at about 200° C and takes about an hour to complete. The second stage is a transformation of the retained austenite to bainite. The first part of the third stage occurs at about 200° C, and involves precipitation of cementite at the same time as the special carbide passes into solution. These further investigations have demonstrated that coarsening and extension of grain boundary cementite films take place concurrently

with solution of cementite particles within the acicular (needle-like) grains inherited from tempered martensite. These phenomena are accompanied by coalescence and spheroidization, which take place more readily in proportion to a reduction in the carbon content of the alloy. The increased ability of carbon to dissolve in ferrite when carbon steels are tempered is believed to result from small carbide size, coherency strain and a departure in carbon content of cementite from the standard formula (Fe_3C).

Tempering and elastic limit

Hardened steels behave in various ways under specific stresses. It has been suggested that the elastic limit and other tensile properties can be regarded as a function of the tempering temperature for plain carbon steels (0·2% to 0·8% C) at tempering temperatures between 200° to 420° C. This question has been studied, and experiments appear to show that the elastic limit is influenced by tempering, and in a manner totally different from the normal tensile properties. The higher the temperature at which a steel can be tempered while retaining its high hardness, the higher is the maximum attainable yield strength.

Low carbon martensites

Reducing the carbon content to a maximum of 0·2% has led to the introduction of a new class of quenched and tempered martensitic steels having improved engineering properties combining strength and ability to be formed and welded. These steels are so tough that they are beginning to be employed in the construction of pressure vessels, and are known as "low carbon martensites". The novel characteristics of these steels have led metallurgists to re-examine martensite, with the result that it is now known that the medium carbon type of martensite, with low temper, may possess high tenacity combined with exceptionally high strength.

Quench tempering

Further study has revealed that the lower hardness and developing modification of the structure of the low carbon martensites with increasing thickness are the result of an unavoidable tempering during quenching. This form of tempering is known as "quench tempering", and it takes place during the same quenching operation as that in which the low carbon martensite is formed. It produces a mottling of the martensitic matrix and a fine precipitate of tiny cementite "straws" in various plates. The extent to which quench tempering occurs is governed by the temperature of martensite formation and the later rate of cooling.

The same phenomenon has been observed in other low carbon alloy steels, with effects on both the microstructure and the properties of the low carbon martensites.

Hardness of tempered martensite

These investigations also bear upon another set of researches, namely into the hardness of tempered martensite in carbon and low-alloy steels. Steels with more than about 0·2% carbon are so brittle when quenched that they cannot be used, and must be tempered to give them a more tenacious structure. The tempering temperature used is often chosen at random, and hardness is commonly taken as the standard from which the other mechanical properties are deduced. Because time and temperature of quenching are interconnected variables modifying the result, it has been difficult to make a quantitative evaluation of the influence of carbon and alloying elements on the degree of softness produced in the materials by tempering. Now, however, the temperature-time effect has been combined into a single functional variable or parameter. This has greatly simplified the problem and has rendered it possible to develop an empirical method for estimating, within limits, from the chemical composition of the steel, the hardness of tempered martensite developed.

The steels concerned are those having a total alloy content below 5%. The resistance to softening or tempering can now be expressed as a hardness increment. The method is restricted to a tempering temperature range of 340° to 650° C and to a composition range of 0·2% to 0·85% carbon.

Tempering iron-carbon alloys

We have seen earlier that the tempering of iron carbon alloys can be divided into three stages, all dependent on time and temperature. Changes in the martensite in these alloys occurs only in the first and third stages. Many research workers have observed the extreme diffuseness of X-ray patterns from quenched and slightly tempered steels, but the relation of this "line" to its basic causes has not been satisfactorily determined. In general, it is now known that as distinct from factors relating to the instruments used, the broadening is produced by variations in lattice parameters owing to local internal strains, known as strain broadening; and imprecision in meeting the Laue condition (particle size broadening). Broadening in powder patterns may also result from a composition lacking in homogeneity and the overlapping of tetragonal doublets.

X-ray investigations

Investigation into the tempering of martensite crystals by means of X-rays has shown that neither the strain nor the particle size varies with the carbon content of the alloy, and each is also independent of the temperature at which the first stage of tempering is completed. The broadening caused by particle size quickly vanishes during the third tempering stage, while the strain persists to high temperatures. The character of the strain relief seems comparable to that of recovery in cold-worked metals. It has been suggested that the elastic limit and the residual strain are inversely connected.

Temper embrittlement

The term "temper embrittlement" is used for the injurious effect on the impact properties of a tempered low-alloy steel when the material is either gradually cooled through a temperature region of 680° to 370° C or isothermally maintained at this temperature for a protracted period of time. The result is often a brittle fracture. The explanation of temper embrittlement has never been fully revealed and of late investigators have studied the effect of carbon on this form of embrittlement in a steel open to its influence. Briefly summarized, this form of embrittlement is apparently caused by a strain across prior austenite grain boundaries at the embrittling temperature. This strain arises from the contraction of the ferrite lattice when alloying elements are eliminated from solution in the ferrite by a reaction with the existing minor carbide phase.

Salt Bath Heat Treatment Equipment and Methods

Salt baths have been widely adopted for various heat treatment processes for ferrous metals in the last fifteen to twenty years. The greatly increased use of the process has resulted from important changes in the method of heating the bath and a series of improvements in the composition of the baths themselves. The present article describes their advantages (and disadvantages) and goes on to consider salt bath operation and applications

By A. G. GARDNER, A.I.M.

THERE are radical differences between the heat-transfer characteristics of conventional furnaces and those of liquid baths which favour the latter medium for some classes of heat treatment work. The basic characteristics of salt baths may be stated as follows:

(1) *Surface protection.*—All work immersed in molten salt is automatically protected from contact with air, not only whilst in the bath but also after removal from the bath until quenched. This automatic protection is imparted by the salt film which covers the surface of the hot work when it is removed from the bath.

Quenching rate is not retarded if the quenching liquid removes the salt-coating rapidly.

(2) *Automatic preheating.*—Due to the high melting point of most salts, a layer of frozen salt forms on the surface of the cold work immediately it is immersed in the bath. This frozen salt is a poor conductor and retards the initial heating rate until the surface of the work reaches a temperature approaching the melting point of the salt. This means that the thermal shock normally sustained in the initial heating of a piece with varying section is greatly reduced.

(3) *Uniform heating rate.*—Since liquid salt surrounds the work, heat is transmitted to all surfaces simultaneously.

(4) *Rapid heating.*—The actual rate of heating will, of course, depend on the conductivity of the metal itself, but a salt bath will heat work at least four times faster than a radiant furnace operating at the same temperature. As an example, a 1 in. dia steel bar can be heated uniformly to 800° C in slightly more than three minutes in a salt bath.

This feature of rapid heating is not always desirable, but it is an advantage with parts requiring localized heating. For steels liable to warping or cracking when rapidly heated, a controlled atmosphere furnace is preferable.

(5) *Buoyancy.*—The density of molten salts ranges from 1½–3 times that of water. Whilst all ferrous metals readily sink in molten salt, they are nevertheless supported by a considerable degree of buoyancy. Thus, a 10 lb workpiece when immersed in a neutral chloride bath weighs only 6 lb. This reduces the risk of distortion or warpage.

There are disadvantages connected with salt baths which should also be mentioned:

(1) Contamination of quenching liquids by salts which adhere to articles to be quenched and dissolve in the quenching liquid.

(2) Articles must be perfectly dry before entering the salt bath, and preferably preheated slightly. This is because of the danger of the violent reaction which can occur due to the sudden generation of steam.

Fig. 1.—Externally heated electrical salt bath, having inside dimensions 16 in. dia and 18 in. deep

(3) There is a fluxing action on refractories if a certain safe temperature is exceeded. This only applies to furnaces with a refractory container for the salts and adds to the cost of maintenance.

(4) Certain shapes cannot be satisfactorily treated in salt, either because they would float or because they would "drag out" an excessive amount of salt. Some drag-out losses occur in any event and vary with the degree of viscosity of the salt and with the shape of the work. The losses amount to between 4 and 24 oz of salt per 100 lb of work.

(5) There is always a certain amount of corrosive action at the surface of a salt bath, resulting in attack on containers, thermo-couple sheaths, hooks and partly-immersed work. This attack increases in severity with temperature.

The solid salts are liquefied by heating them in a suitable container. This forms a bath in which workpieces may be heated to the temperature specified for

their heat treatment. If pure salts are used, each of these has a definite melting point which is constant. A large variety of salts are available for a wide range of temperatures and this may be extended by choosing suitable salt mixtures.

Salt bath classification

Salt baths may conveniently be divided into three classes: low, medium and high temperature, and these will now be briefly described.

(1) *Low temperature.*—These baths are normally operated below 590° C since above this temperature the steels and container are attacked by the salt. Baths of this type are used for tempering carbon steels and low-alloy steels.

Fig. 2.—Close-up interior view of the furnace chamber of the salt bath shown in Fig. 1. The spirally grooved lining retains the heating elements in position

The salts used consist of mixtures of nitrates and nitrites of alkali metals. For low-temperature work down to about 150° C, a mixture of 56% potassium nitrate and 44% sodium nitrite can be used. If the temperature required is in excess of 220° C, then a mixture of 51·3% potassium nitrate and 48·7% sodium nitrite is quite satisfactory and is also somewhat less expensive.

(2) *Medium temperature.*—The temperature range covered by these baths is approximately 600°–900° C. They are used for hardening, normalizing or annealing carbon steels and low-alloy steels. Also for quenching high-speed steels. The salts used are normally chlorides or mixtures of chlorides and carbonates. A typical bath would contain 56% calcium chloride and 44% sodium chloride.

The maximum temperature of 900° C quoted above should not be exceeded otherwise atmospheric oxygen is absorbed and causes decarburization of steel parts immersed in the bath. Should this occur, the addition of a rectifying agent such as fused borax, boracic acid or boric oxide can be used providing the salt mixture does not contain carbonates.

(3) *High temperature.*—These baths are operated at temperatures in excess of 900° C and are used for hardening high-alloy and high-speed steels. They are also used for preheating. Mixtures of barium chloride, borax, sodium fluoride and silicates are used and occasionally magnesia or lime is added. A mixture of 83% barium chloride and 17% barium fluoride melts at 844° C, whilst 48% calcium fluoride and 52% magnesium fluoride melts at 947° C.

Some of the baths may attack steel, but this only occurs when they are freshly made. Oxidizing reactions can be prevented by rectifiers containing ferro-silicon.

Types of salt bath furnace

Salt baths may be heated by oil, gas, or electricity. Oil-firing is more suitable for large than for small-size baths owing to the length of the flame. Gas is frequently used quite satisfactorily. Electrically-heated baths are available with either external or internal heating, a difficulty with the former being preventing molten salt coming into contact with the resistors. Salt baths which are heated internally by electricity utilize either immersed heaters or electrodes and these methods lead to rapid heating of the bath. Examples of the various types will now be described.

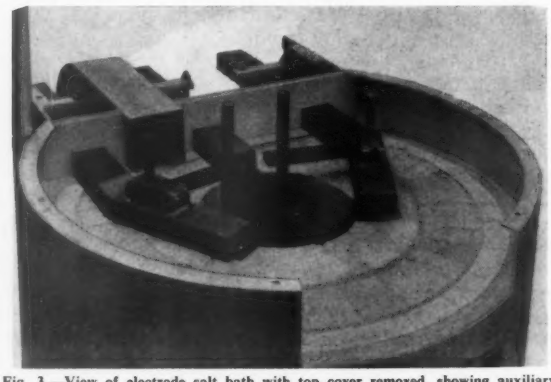


Fig. 3.—View of electrode salt bath with top cover removed, showing auxiliary starting electrodes in position

Electrically heated

(a) *External heaters.*—This type is adapted for working temperatures up to a maximum of 900° C. The usual arrangement consists of an insulated refractory chamber fitted with radiant electric heating elements, surrounding a heat-resisting cylindrical pot. Automatic temperature control is recommended and this, combined with uniform heating and the absence of flame attack, gives the pot an appreciably longer life than is obtained in fuel-fired units, and ensures minimum salt consumption. Fig. 1 shows one of these salt baths whilst Fig. 2 is a close-up interior view of the furnace chamber, showing the helically-grooved lining which retains the heating elements in position. The latter are formed of one continuous helix of extra-heavy nickel-chromium rod and so apportioned round the chamber as to achieve a uniform dissipation of heat. Element terminals of large-diameter nickel-chrome rod are brought to the outside of the furnace through special tubes, backed with

asbestos, to prevent heat loss and short circuiting. The furnaces are protected against overheating by a safety fuse.

These furnaces are available with Calorized mild steel pots or nickel-chrome steel cast pots, both types having a flange seal to prevent seepage of the liquid medium into the furnace brickwork. Hinged split covers are provided carried on a back pivot to allow them to be swung aside clear of the top of the pot. If required, a hood can be fitted to the furnace to protect the operator from the fumes of the molten liquid, and a jib crane to facilitate loading and unloading operations.

Salt baths of this type are adapted for many heat-treatment operations including hardening, preheating, carburizing, etc. They are extremely simple to operate, have a high thermal efficiency, and occupy a minimum of floor space.

(b) *Internal resistance heaters.*—Salt baths heated internally with immersed heaters use resistance elements encased in tubes of suitable metals. This type of construction can be used from about 150° to 550° C, and is well-suited for the heat treatment of aluminium alloys and other applications in the low-temperature field.

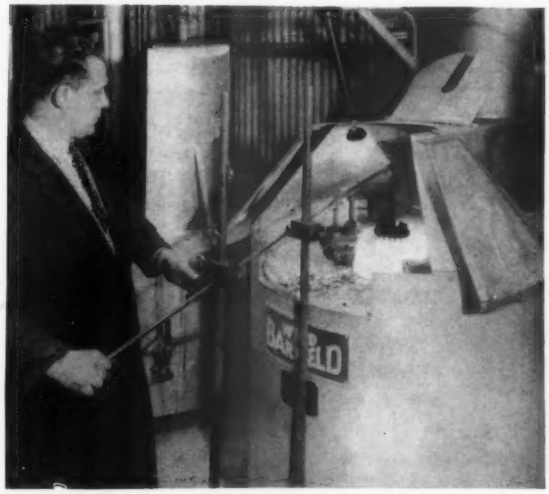


Fig. 4.—Removing parts from electrode salt bath after heat treatment

Heaters take the form of tubular units which are arranged either in the bottom of the bath, thus promoting a strong circulation of the liquid salt, or round the sides of the bath. Direct immersion heaters in the salt ensure a long pot life because the more event heating results in lower thermal stresses.

(c) *Immersed electrode heaters.*—This type of salt bath is widely employed for hardening operations of all kinds. In these baths the molten salt itself forms the resistance element, being heated by the passage of a low-voltage alternating current between immersed electrodes. The latter are closely spaced in pairs to produce electromagnetic conditions between them which produce an automatic stirring action throughout the entire bath. Liquid salt is drawn down and through the area between the electrodes and an extremely active circulation is set up. This takes the heat away from the region of the electrodes as fast as it is generated and no measurable temperature gradient exists between the main body of the bath and the electrode area.

An electrode furnace must operate from alternating current in order to avoid electrolysis (decomposition) of the salt. A step-down transformer is used to give low secondary voltages in the range 5–20 volts, depending on the conditions.

As heat is generated directly in the salt, this allows great flexibility in designing the shape of pot; and size and shape of furnace are practically unlimited. Where the depth is about 6 ft or less the electrodes are mounted on one level, whilst deeper furnaces have submerged electrodes in pairs, one above the other, in order to ensure uniform temperature distribution and assist remelting of a solidified bath.

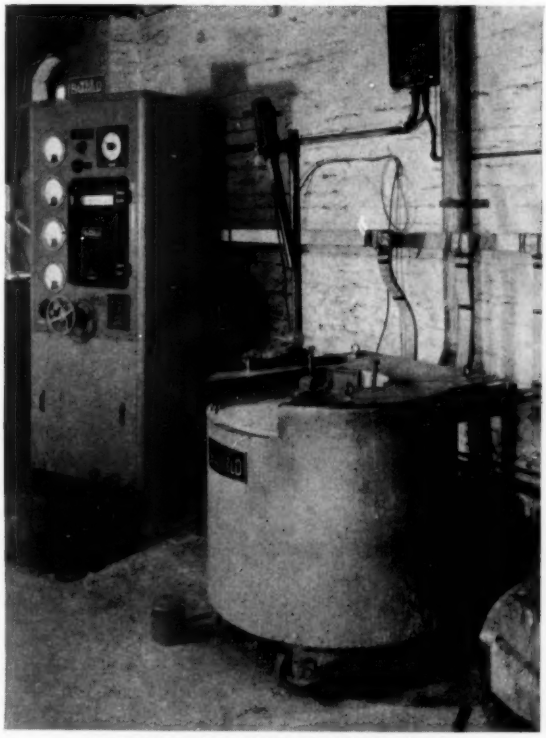


Fig. 5.—General view of electrode salt bath equipment

When starting a bath up from cold, the usual practice is to have a pair of removable auxiliary electrodes arranged to form a short circuit path through a portion of the salt on top of the bath. After the top zone is melted, liquid salt is presented to the first lower tier or main electrodes which are then switched on and in turn melt the salt in that zone. Where more than one set of electrodes are provided this procedure continues until the entire bath is melted.

Fig. 3 shows a view of an electrode salt bath with the top cover removed and with auxiliary starting electrodes in position. Figures 4 and 5 are typical installation views of electrode salt bath equipment.

Oil-fired and gas-heated salt baths

These two forms of heating are usually employed for baths suitable for temperatures up to a maximum of about 600° C. This includes such applications as the

heat treatment of aluminium and its alloys, spring tempering, and quenching light articles of carbon steel after they have been raised to the hardening temperature.

Fig. 6 shows a small salt bath heated by a series of natural draught hatchet type burners designed to consume town's gas at a supply pressure of 2–3 in. water gauge, air under pressure not being required. Each burner is fitted with a tap but main control is obtained by a quadrant type valve in the supply line.

Larger baths are generally heated by powerful natural draught burners fitted along each side of the furnace and arranged to fire into passages beneath the pot alternately from each side, thus ensuring even heating conditions. Each burner is under separate control and the burners are suitable for burning town's gas at supply pressure. Air blast burners can be fitted where rapid heating up is required and these are shut off when the working temperature has been reached, since the latter can then be maintained by the natural draught burners. On these larger baths, preheated secondary air is mixed with the primary air/gas mixture as an aid to more efficient combustion.

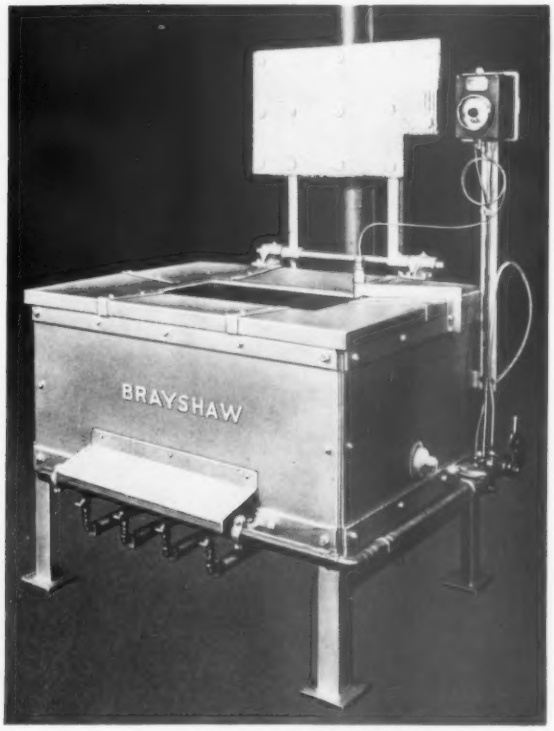


Fig. 6.—Small gas heated salt bath

With oil-fired salt baths, air at a pressure of about 28 in. water gauge from a high-pressure fan is required. The burner equipment is arranged to project the flame into a refractory lined combustion chamber constructed beneath the pot. The products of combustion pass into the chamber surrounding the pot and through the uptake ports at either side, which are under separate control and adjustable to give even temperature distribution throughout the length of the installation. Fig. 7 shows an oil-fired tempering bath.

Application of salt baths for normal heat-treatment operations

The principal heat-treatment operations of annealing, quenching and case-hardening can often be advantageously carried out in salt baths. Their rapid heating rate and ability to operate at maximum permissible temperatures minimizes the time required for the operations. These factors, together with the low proportional mass of baskets or fixtures means that a small, comparatively inexpensive unit can handle large quantities of work.

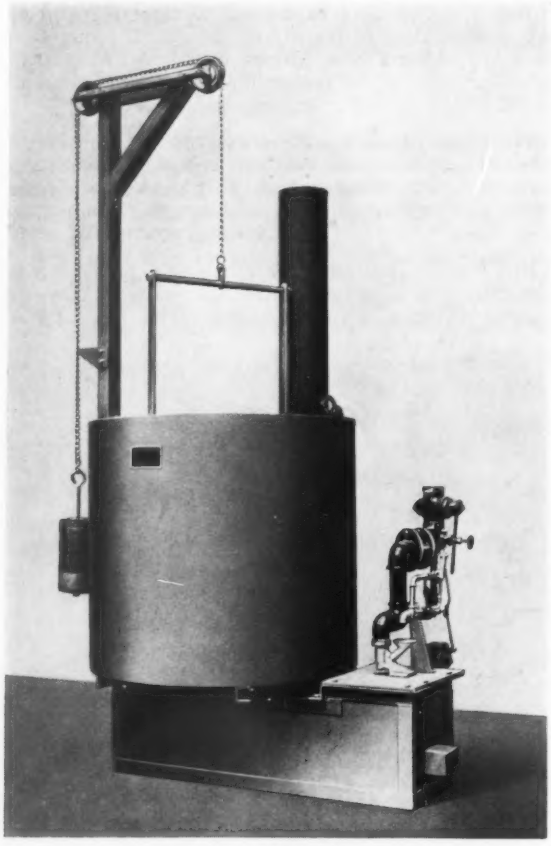


Fig. 7.—Oil fired salt bath

In addition to the heat treatment of steel, salt baths may conveniently be used for the heat treatment of aluminium alloys for aircraft work.

Annealing

This operation, as distinct from cyclic annealing, is of limited application (especially where slow cooling from above the critical temperature is required) because of the large heat capacity of the salt bath.

The majority of installations are for process annealing for relief of cold working stresses, and the operations are carried out below the critical point of the steel. The heating cycle is short, usually less than one hour, and the work can be rapidly cooled in air or water without hardening. The surface of the work is left clean and bright. The annealing of low, medium and high carbon steel wire or rod in coils is one of the most useful applications. Stainless steel and nickel-chromium alloys can

also be successfully annealed by salt bath immersion. The temperature range is between 800° and 1150° C for approximately 30 min, the work being quenched directly into water. Although some tarnish is produced on the surface, it can be removed by a light acid dip.

Neutral hardening

Where steel components must be hardened without affecting their surfaces in any way, either by oxidation or change in carbon content, the process is referred to as neutral hardening. For this to be carried out in a salt bath, the salt must be neutral to the steel and serve only as a heating medium. A mixture of chlorides is generally used and undesirable dissolved oxides or oxygen are often removed from the bath by precipitation treatment.

Neutral hardening corresponds to controlled atmosphere heating and is required for a wide variety of applications which include carbon and alloy steels, die steels, stainless steel and cast iron. The advantages of using a salt bath for this type of treatment include elimination of atmosphere generators, high capacity of equipment, and inherent control of distortion.

Hardening of high-speed steels

This most exacting hardening operation is rendered more reproducible, efficient and economic by salt bath technique.

The main requirement of steels with relatively high tungsten content is that of slow initial heating to a temperature in the range of 850°–900° C followed by a rise in temperature to that required for hardening in the shortest possible time. Preheating is usually carried out in two stages—firstly to 400° C and then to 850°–900° C, and alternative forms of heating may be used. The first stage preheat can be conveniently carried out in a forced air circulation furnace and a low-temperature salt bath may be used for the second stage. The tools are next transferred to the salt bath already at the working temperature of 1150°–1350° C, according to the tungsten content. Due to the high rate of heat transference from salt to work, the desired rapid rate of heating is achieved. Hardening temperatures for the various grades of steel are usually lower when salt bath heating is adopted as compared with the use of radiation furnaces. After the tools have attained the hardening temperature, they are removed and may be quenched in air blast, oil or salt bath, according to the steel and the nature of the tools. As the tools are covered with a thin film of salt on removal from the bath, they are given complete protection against oxidation. Subsequent secondary hardening operations may be carried out in a low-temperature salt bath or a forced air circulation furnace.

Any of the tool steels including the tungsten, molybdenum or cobalt types can be hardened with equal ease merely by changing the temperature setting of the furnace. Internal stresses in the finished parts are negligible if another salt bath is used for the quench (600°–650° C) and by this means cracked tools are rare.

Accurate control of the highest temperature bath is very important since the operating temperature is very close to the melting point of the steel. A typical arrangement would be as follows: The standard pyrometer consists of a lens type fixed-focus radiation instrument, the receiving tube of which is mounted at the side of the bath and focused on the surface of the molten salt. A thermocouple on the receiving tube is connected to the indicator, which is mounted on the pyrometer panel. This instrument has one scale calibrated for the receiving tube and another scale calibrated for the check thermocouple. This arrangement enables an allowance to be made for the fact that the surface of the salt is at a slightly lower temperature than the main mass. In operation, the dip-type check thermo couple is immersed in the molten salt from time to time and the true reading noted on the check range scale of the pyrometer indicator.

Automatic temperature control is also available to enable the operator to give maximum attention to the actual heat treatment.

Carburizing

Liquid carburizing, in principle, is the same as pack carburizing or gas carburizing, since carbon is added to the surface to the required depth. In all industrially operated baths, the carburizing medium consists of cyanides. Originally, only sodium cyanide was used, and this type of bath is still employed for obtaining light cases up to 0·010 in. deep when the process is known as cyaniding and will be described later. These baths usually operate within the temperature range 730°–885° C, and the cases consist of both carbides and nitrides. The latter predominate when the lower temperatures are used whilst at the higher end of the range carbides form the major portion of the case. A plain cyaniding bath should not, however, be confused with a liquid carburizing bath.

True liquid carburizing baths are activated or catalysed. For cases of moderate depth up to about 0·040 in. they usually contain barium compounds, although when water-soluble materials are required for ease of removal from the surface, acidic oxides, phosphates or fluorides can be used. Cases produced in activated baths contain a smaller proportion of nitrides than those produced in cyanide baths. The cases are also less brittle and more nearly resemble those obtained in pack and gas carburizing.

For heavy cases, all liquid baths contain barium catalysts. These baths have low cyanide contents averaging between 8% and 12% and operate in the higher end of the temperature range from 929° to 955° C, with a few installations operating at 980° C. The bath should always be covered with powdered carbon or graphite to conserve heat and protect it from excessive contact with the air. This procedure is generally employed for cases between 0·030 in. and 0·100 in., although deeper cases can be produced. While there is not complete agreement on the exact mechanism of carburization by a liquid bath, it does appear that active carbon is produced and this enters the steel without any sooting.

As a result of the intimate contact between the liquid bath and the steel, the temperature of the latter is rapidly raised by conduction to the carburizing temperature. Since liquid carburizing baths also operate generally at higher temperatures than are used in gas carburizing, case formation and diffusion are more rapid.

One of the most important characteristics of liquid carburizing lies in the uniform case it produces, regardless of how densely the work is loaded or how intricate the surface: basket loading is common. In any event, the work can be as densely loaded as mechanical reasons permit. This results in a very efficient and adaptable set-up. It is a simple matter to handle simultaneously work in batches, each requiring its characteristic case depth, since it is easy to immerse various charges in the bath for the proper time.

Cyaniding

This is a process for imparting a shallow, file-hard case on the surface of steel in a relatively short time. It

is carried out in a bath containing from 15% to 30% of sodium cyanide. A case depth of about 0·010 in. is as much as can be expected. The effect is due to a combination of nitriding and carburizing which accounts for its extreme hardness.

Cyaniding baths are usually equipped with plain welded steel pots which have an excellent life. This is attributed to the fact that the steel plate is protected by the scale which forms on the outside surfaces, whilst the inner surfaces are protected from oxidation by the carbon monoxide gas generated in the cyanide bath. Good fume exhaust hoods are essential.

Batch-type furnaces are most generally used because they can handle relatively large production in a compartively small furnace.

In general, cyaniding is used to secure a shallow and cheap wear-resisting surface of high quality. Such components as screws, dental burrs, sewing machine parts, shafts, and bolts, are some examples of the many items which are cyanided.

Application of salt baths for interrupted quenching

Having dealt with the adaptability of salt baths to handle conventional heat treatment operations, the more recently developed methods of performing austempering, martempering and cyclic annealing will now be described, together with a few comments on solution treatment for age hardenable alloys.

Interrupted quenching treatments are based on the rapid cooling of the work to a selected temperature by quenching in hot salt. The effectiveness of such operations depends on the cooling power of molten salt at temperatures above 150° C. The cooling rate in the critical range between 750° and 350° C is higher in a modern isothermal salt quench bath, *properly agitated*, than in hot oil. The layer of hot salt in immediate proximity to the hot steel surface must be constantly replaced by fresh quench liquid. Not only does the salt bath extract heat rapidly from metal being quenched but it also dissipates this heat so rapidly that the bath is kept within 3° C of the desired temperature.

The three principal types of interrupted quenching processes in use at the present time are as follows:

(1) *Cyclic annealing*.—This produces a soft and easily controlled structure with a very short time cycle. It requires the highest temperature in the quench. The steel is heated first to the austenizing temperature (approximately 820° C) and then quenched in another bath operating in the range of 600°–700° C, where it remains for the time indicated by the S-curve for that particular steel to complete transformation. The austenite transforms directly to the desired soft structure of ferrite and pearlite. Finally, the work can be cooled in air or water as rapidly as possible. Depending on the composition of the steel, the total cyclic annealing operation requires from 30 min to a few hours. The process has been used on a commercial scale for cast-iron cylinder sleeves and piston rings, as well as wrought steel products.

(2) *Austempering*.—This provides for medium hardness combined with ductility and toughness and a good control of distortion. It requires medium temperatures in the bath. The process is used for small or thin parts where hardness requirements fall between 35 and 50 Rockwell-C, and where toughness or ability to bend without breaking is a requirement. Such parts as typewriter parts, open-ended and socket wrenches, pliers and lawn-mower blades are suitable subjects for austempering. The steel is generally of medium carbon content, although low-alloy steels are occasionally used. The components are quenched in a bath maintained between 400° and 520° C and kept in the bath until transformation is complete, no further tempering being necessary.

(3) *Martempering*.—This method provides high hardness equal to oil quenching, with greatly reduced distortion and practically no residual stresses in the hardened piece. It requires the lowest temperatures in the quenching bath.

The steel is quenched into a salt bath maintained at a temperature slightly above that at which martensite is formed (the Ms temperature). This technique depends on the fact that cracking and distortion in normal quenching result to a large degree from the temperature gradients existing in the piece while the martensite is forming. Internal stresses are minimized in martempering because the temperature throughout the component is made uniform just before martensite formation starts.

The steel is, therefore, allowed to remain in the bath until the temperature has become practically uniform throughout the part: generally a minimum time of 5 min per in. of section. The steel is afterwards removed from the bath and allowed to cool slowly, usually in air, to form martensite.

One of the most promising fields for martempering is the one which combines it with carburizing. For example, an enormous quantity of gears are carburized and hardened which must then be finished by grinding or lapping to extremely close tolerances. A very substantial saving can be secured by a martempering quench direct from the carburizing bath.

Solution heat treatment.—Salt baths are a preferred method for heating alloys which are susceptible to age hardening. Their function is to place all the constituents of the alloy into a homogeneous solid solution. After quenching to retain the solid solution, the alloy is warmed (tempered or aged) and enough insoluble constituents precipitated in highly dispersed form to harden and strengthen the metal.

This treatment is applied commercially to non-ferrous alloys, principally of aluminium and copper.

Salt bath operational notes

In conclusion, some notes are given below regarding correct operational procedure.

Every kind of foreign substance must be excluded from the bath. Cyanide salts must never be allowed to enter nitrate baths as serious explosions can occur. The purest available salt should always be used. Salts of one temperature range must not be mixed with those of another. Nitrates should be absent from medium- and high-temperature baths. Corrosive impurities such as sulphates, and nitrates (in higher temperature baths) if present, can be eliminated by adding clean, dry, cast iron chips to the bath (1/20 of the total weight of molten salt in the bath). When the bath is nearly at its maximum working temperature, the chips should be stirred in vigorously and the sediment which forms is allowed to sink and then removed.

Preliminary heating of the bath must be gradual; too fast a rate can result in overheating of the container and does not hasten melting of the salts. Local overheating results in local changes in composition of the salts and hence lack of uniformity in the bath.

When new additions are made to molten salt, mild explosions can occur and care must be taken to ensure such additions are perfectly dry. Whenever possible it is best to make additions when the salt bath is solid.

When large articles are to be heated or when there is only a small margin between the melting point of the bath and the maximum working temperature, a thick coating of salt can form on the work which requires time to re-melt. Low-melting-point salt mixtures are preferable for such work as early disappearance of the solid coating is then facilitated. The difficulty may be lessened where practicable by preheating the work to the melting point of the bath.

Periodical tests should be made, both chemical and physical, of the salt bath. Thermo couple sheaths should be removed before the salt is allowed to solidify.

When a bath of molten salts is used, not only may the required temperature be accurately obtained, but uniformity of temperature throughout the bath is not difficult to secure owing to the distribution of heat by conduction and convection. However, the temperature of the bath is lowered whenever cold steel articles are introduced and time must be allowed for its restoration to the required value. The length of this additional period depends on the size and composition of the articles undergoing treatment. For cutting tools it is approximately 1¾ min/in. of cross-section.

In parts having inequality of section, the sudden change when introduced into a salt bath would result in the thinner sections expanding in advance of the thicker sections and producing distortion. This can be avoided by:

(a) Preheating such parts gradually to 300° C; or

(b) Immersing them in a bath at a lower temperature and raising the temperature to that required for hardening.

Distortion may also occur as a result of passing through steel transition points too suddenly as a result of rapid heating. This can be avoided by bringing the articles to a uniform temperature just below the transition point, through which it may then be allowed to pass.

In conclusion, the author would like to thank Brayshaw Furnaces & Tools Limited of Manchester for supplying the photographs of their equipment shown in Figs. 1, 2, 6, and 7, and Wild-Barfield Electric Furnaces Limited of Watford for supplying the photographs of their salt baths reproduced in Figs. 3, 4, and 5.

Automatic Blow-down Valve is Boiler Feed Controlled

An important advance in boiler house blow-down procedure has been made by the Carron Company, Falkirk, Stirlingshire, with their Carron-Smith automatic blow-down valve. The valve is operated by the supply and pressure of the boiler feedwater thus establishing a definite relationship between the amount of water blown down and the amount of feedwater being introduced.

The design and functioning of the valve will be made apparent by referring to Fig. 1. The feed pump pressure is connected to the lower pressure chamber on the underside of rubber diaphragm E via the connexion V. Any movement of diaphragm correspondingly affects the spindle O to which it is connected, operating against the spring L.

There is a bleed from the feed pressure to the upper pressure chamber on top of diaphragm through the port K where the amount of water entering the top chamber is controlled by an orifice plug H. When the diaphragm is forced up by the feed pressure in the lower chamber, a small quantity of the water in the upper chamber is forced out via the release ports G and the discharge pipe A until the pressure release valve M is closed. The diaphragm has now reached its upper position, this being regulated by the top of the valve spindle coming in contact with the underside of the release cylinder at F.

The pressure now gradually builds up in the upper chamber via the orifice plug H, keeping the release valve M on its seat, and as the pressures in the upper and lower chambers gradually equalize, the spring L forces the diaphragm and the spindle O downwards, thus closing the blow-down opening R. The frequency of this operation is regulated by the orifice plug H.

Before the bevelled seat on the spindle O is arrested at S, the needle of the spindle O penetrates the blow-down orifice T, thus removing any obstruction which might have lodged there. The pressure release valve operating nuts C and the release spring N force the release valve off its seat, which allows a small quantity of water from the upper chamber to escape through stabilizer valve D to atmosphere. When the pressure in the top chamber is released, the diaphragm is again forced up by the feed pressure in the lower chamber, and the cycle is complete.

The size of the blow-down orifice discs controls the amount of water blown down and is governed by various steaming factors such as hardness of raw water, percentage of condensate returned, etc. The normal sizes which are supplied are $\frac{3}{64}$, $\frac{1}{16}$ and $\frac{5}{64}$ in.

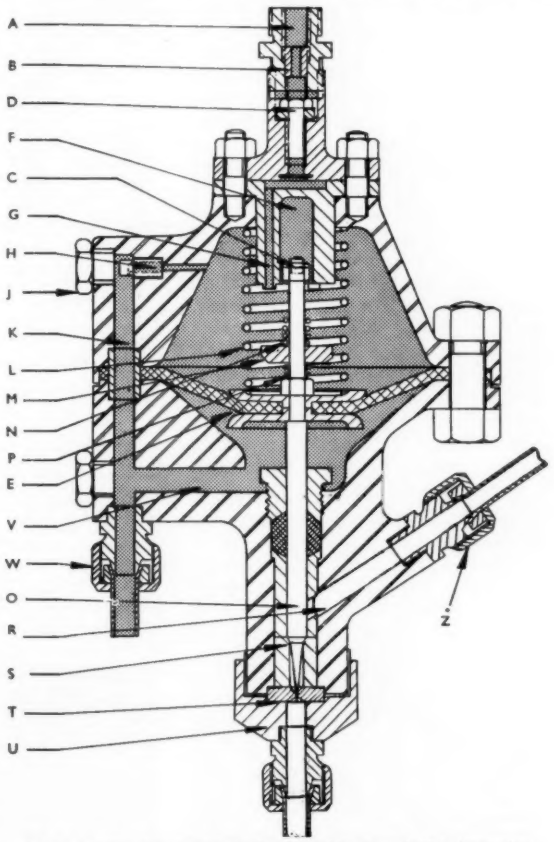


Fig. 1.—Section view showing the Carron-Smith automatic blow-down valve.

The valve body is manufactured in phosphor bronze, PB3, and all internal working parts are made of either Monel metal or stainless steel. The valve conforms to Lloyd's Register requirements and is marketed at £60.

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Protective Interlocking of Alternative Supplies

Occasions may arise when it is desired to connect alternative supplies of electricity to a particular system and to ensure that the arrangement is such that the two supplies cannot be inadvertently connected together. It may, for instance, be required to have an alternative supply to connect immediately and automatically to a set of busbars in the event of the usual supply failing. A scheme whereby an instantaneous change-over can be effected is illustrated in Fig. 1. The two supplies are connected to the bars via fuses, contactors and isolating switches. The contactors are solenoid operated and each control circuit incorporates an auxiliary interlock which is closed when the contactor is open. The operating coil of each contactor is fed from its own supply and connected in series with the interlock on the other contactor, thereby ensuring that when one contactor is closed, the coil of the other contactor is de-energized, thus rendering it impossible for both contactors to close at the same time. If the usual (No.1) supply fails, No. 1 contactor will open, thereby closing its interlock and completing the control circuit of No. 2 contactor coil, bringing the alternative supply into use. At the same time, the opening of No. 2 interlock will open circuit the No. 1 contactor coil circuit. By fitting tumbler switches in the contactor coil circuits, either supply can be readily isolated to permit maintenance of contactors, etc. The contactors should be of the gravity drop-off type, and a light pull-off spring fitted to overcome inertia, whilst contacts and interlocks should be adjusted to minimum travel consistent with safe operation. This will ensure a sufficiently rapid change over to prevent any undue disturbance to plant connected to the busbars.

A somewhat different case would be the need to provide for the transmission of two alternative sources of supply over the same line in opposite directions. This can be

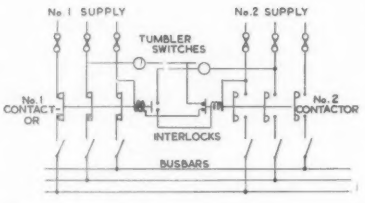


Fig. 1.—Scheme for instantaneous supply changeover

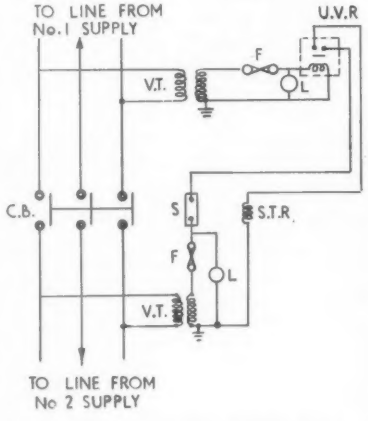


Fig. 2.—Scheme for protective interlocking of two alternative sources of supply over the same lines in opposite directions. CB circuit breaker; VT, voltage transformer; UVR, under voltage relay; STR, shunt trip release (no close feature); S, auxiliary switch to open just before main contacts close; F, fuses; L, pilot lamps (to indicate sound fuses)

effected by the use of a circuit-breaker incorporating a "No close" feature for the purpose of affording protection against the closing of the circuit-breaker in the event of both sides of the circuit-breaker being energized from the two different sources of supply at the same time. Referring to Fig. 2 it will be seen that when both sides of the circuit-breaker are energized the shunt trip relay is energized and under these conditions the switch cannot be closed. When either side of the circuit-breaker is "dead" the shunt trip relay will not be energized and the switch may be closed. Special attention should be drawn to the provision of the two pilot lamps L,L, as without these, if either of the two auxiliary fuses becomes open-circuited, then even though both sides of the circuit-breaker are energized, the shunt trip relay will remain de-energized and the switch may be closed under wrong conditions. The lamps, however, give visual indication that the fuses remain intact. Should a fuse blow, the associated lamp will cease to glow, and the lamp can easily be tested to confirm that it is not defective. This method is preferable to wiring the pilot lamp directly across the fuse, in which case the lamp would light up when the fuse blew, as a lamp may become defective and thereby lead to the wrong assumption that the fuse was in order.

Automatic Centreless Grinding of Ball Pins

Ball pins of the general types shown by Fig. 1 are now automatically ground by the centreless method, and Fig. 2 is a photograph of the machine and equipment which has been designed for the purpose by Arthur Scrivener Limited, Tyburn Road, Birmingham. The basic centreless grinder is a No. 2 machine of the controlled-cycle type which gives an automatic advance of the control wheel at any desired rate of feed and any required rate of stock removal.

For pieces of the type illustrated, it is only the grinding wheel which has to be formed for the spherical end, the necessary contact with the control wheel being adequately maintained by the form shown in Fig. 3. In the case of the grinding wheel, the taper form is obtained from a suitably ground former plate, while the spherical portion is generated by means of the radius-truing attachment shown by Fig. 4. This attachment is not only suitable for truing the wheel for both male and female diameters up to some 1¼ in. but it possesses the advantage that such diameters can be struck from any point along the width of the wheel.

The workpieces are fed to the grinding machine in a series of

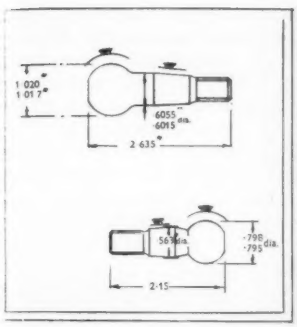


Fig. 1.—Typical ball pins

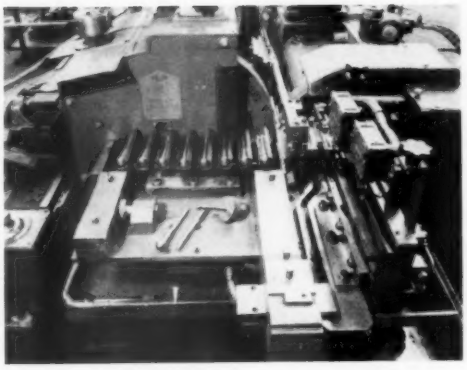


Fig. 2.—(right) Centreless grinder with equipment for the automatic feeding and grinding of ball pins

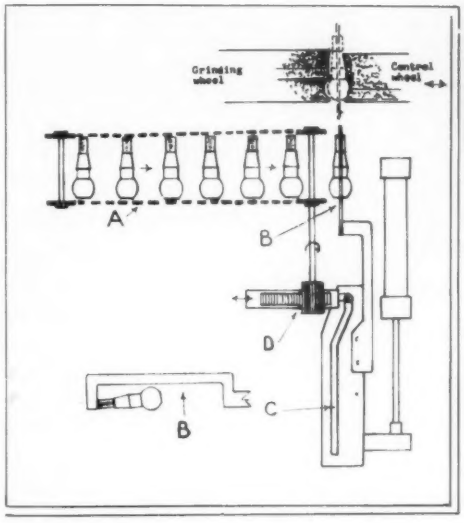


Fig. 3.—(left) Diagram illustrating working principle

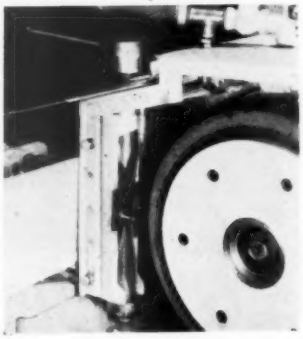
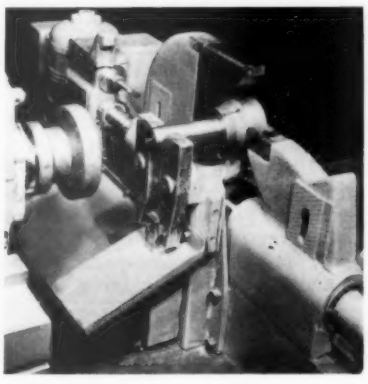


Fig. 4.—Radius-truing attachment applied to grinding wheel

cradles carried on an endless chain conveyor A. On arriving at the end position in line with the grinding throat, the piece is advanced on to the workplate between the wheels by the hooked pusher B. Once the piece is in position the control wheel moves forward to bring it into contact with the grinding wheel by the operation of the controlled-cycle mechanism, and when the grinding operation is completed the wheels again open to release the piece which is pulled back to its original position on the end cradle by the withdrawal of the pusher. The latter, which is hydraulically operated, has a cam C attached, and on repeating the cycle the push feed in advancing first indexes the conveyor, depositing the finished-ground piece into the discharge chute and at the same time bringing a fresh workpiece into position in the gapped push feeder.

Automatic Work Setting for Facing and Centring

Facing and centring operations on the outer bell race forging of a well-known universal coupling are done on a specialized version of the single ended SC2 Endomatic machine made by Douglas Fraser & Sons Limited, Arbroath, Scotland. The machine has a spotfacing and centring head, electrical control panel and the Fraser self-centring power operated vice unit.



The spotfacing and centring head has a speed range of 314/1105 rpm, through medium pick-off gears from a 3 hp motor, the spindle being carried in a hydraulically operated quill with a total travel of 3 in. The head carries a self-contained valve unit which provides any ratio of quill movement, from rapid approach to coarse and fine feed rate.

Clamping arrangements are designed for special purpose application since, as will be seen from the accompanying illustration, the component is located and clamped on two widely differing diameters. The difference in diameter between bell and stem is compensated by a cradle which ensures that the component is level and at a common centre height with the work-spindle: the cradle also carries a dead length stop for endwise location of the bell end.

Transverse alignment with the work-spindle is accomplished by the self-centring vice, through its electrically operated torque unit and differential lead screws, whilst the stem is clamped by a special compensating arrangement in which the clamping fingers are closed by the wedging action of a hydraulically actuated floating roller which is arranged to operate in sequence with the machine cycle.

The automatic work cycle follows the sequence: the component is hand loaded in the cradle and the bell end located against the end stop. Depression of the starting button closes the self centring vice, starts the spindle and initiates the advance of the workhead. With the approach of the workhead the stem of the component is rigidly gripped by the compensating clamp. After facing and centring the workhead withdraws and the clamp is automatically released: the "vice open" control button is then depressed, and the workpiece unloaded.

This conversion is designed to produce 89 pieces per hour, working at 80% efficiency.

Single-ended SC2 Endomatic machine. The component is located and clamped on two widely differing diameters and the centre height with the work spindle compensated by a cradle

Mechanical Handling of Molten Wax

A modernization programme has recently been completed at the largest British candle manufacturer, Price's Patent Candle Company Limited, (Belmont Works, Battersea, London SW11) who now produce about a million candles daily. Technical improvements at this 112-year old firm are limited by the fact that candles are basically unchanged and many of the traditional methods are still the best. Art and decorative candles are again in fashion in Britain, as well as traditionally in the East (to which the company exports in quantity). They are still made by pouring, dipping and moulding, the varieties including the "Venetian", "Willow Pattern" and embossed "Dragon" candles, as well as fluted and spiral types for festivals and birthday cakes.

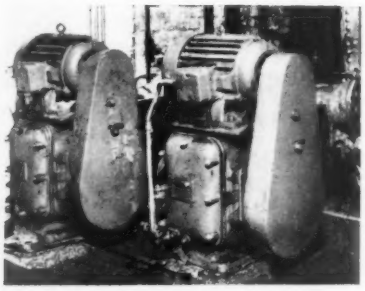
Mechanization of candle moulding is not wholly satisfactory, because the wax must cool slowly or the finished candles will be too fragile. Another limiting factor is that the conical bases of 'self-fitting' candles, intended for easy fitting into different-sized candlesticks, preclude the use of continuous 'wicking' machines. Hand moulds, of course, are still needed for the most elaborate candles.

Wax preparation, however, has fewer difficulties in the way of modern factory organization. At Price's, paraffin wax which is the main raw material—although stearine, spermaceti and beeswax are still used for some products—is heated by open steam-coils in large nine-ton capacity tanks below the boiling house floor level. After filtering it is then pumped to an overhead gallery of blending vats for admixture of sulphuric acid and purification by steam agitation. From the vats, 30–40 ft above the boiling house floor, gravity feed supplies the production side of the factory.

Paraffin wax is a poor heat conductor and tends to solidify locally, with the possibility of complete blockage of the system, and such local accumulation can lead to rapid interference. Two new Megator M.50 pumps, supplied by Megator Pumps and Compressors Limited (43 Berkeley Square, London W1), have been installed to replace the former steam-powered installation. The pump bases are heated externally by steam pipes with additional electric heating tubes internally. All pipelines are traced with heating cable to keep the wax at a temperature of 160–180 °F to prevent it solidifying. Maintenance will normally be carried out during the works annual holiday; the removal of a single cover plate on each pump provides access to all working parts for inspection and servicing as required.

Console for control of pumping and delivery of molten wax

Vat replenishment occupies the pumps a total of 2–3 hr each day, operating at an output of 9 tons/hr. Depending on the level in the tanks, the input varies from gravity feed to slight suction lift. Heating, however, is kept on permanently to ensure a clear system. The control console is directly above the pumps at main floor level and includes the starting switches for the pumps, and controls for distribution to the three main vats of wax for home-trade utility candles, for export quality and for nightlight wax. From the vats the wax is gravity fed to steam-heated jacket pans distributed at the production bays each of which comprise a number of individual stations.



Two megator pumps handling hot paraffin wax at 9 tons hr. Pumps and pipelines are heated

The main recent developments on the production side where—as throughout the works—the plant has been developed by the firm, are in extrusion of crushed or powdered wax for household candles.

Compression of wax blocks for nightlights is another recent improvement. Side by side with these modern operations, festival and other special candles are still hand-dipped and banded or hand-polished in the traditional manner.

Swivelling Bench Vice

A need is often felt on the fitting benches for a vice that will swivel in one or two directions as this overcomes the problem of having various components and assemblies tilted while work is proceeding on them. Again the possibility of holding the work at different heights is also advantageous especially when small items form the main part of the design, and to bring them higher means that less crouching over the vice is needed.

While vices of this type are readily purchased for a price, the construction of a unit of this type is well within the scope of any workshop—in fact the pieces make ideal jobs for the apprentices to attempt and gives them practice with the welding torch in addition to the machining.

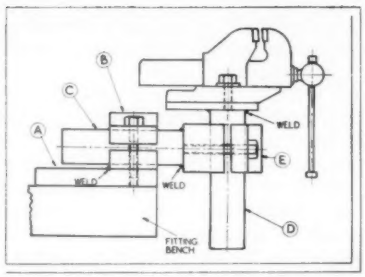
The base member A is merely a flat piece of plate with a block welded on it for the machining of a half bearing, and another block to form the top clamp B needs no further comment other than to point out that $\frac{1}{8}$ in. thick washers between the parts are necessary when boring to ensure that there is a gap when the unit is finally assembled with the shaft C in position.

The latter is another instance where a welded design will give excellent results if a piece of material large enough to turn the shank and leave the vertical half bearing is available. As a slight distortion is of no consequence, bright mild steel for the circular portion is suitable and a generous fillet of welding material will hold it securely to the half-bearing. The cap is fitted in the same way as applied for the bench unit.

The vertical member D is of similar design to C but the platform will depend on the size and hole

centres of the vice, thus a check is needed before proceeding with any machining. One point is, however, rather important. A surface as large, or at least nearly as large as the vice is necessary because adequate support is not obtained if the platform does not cover the vice base, and a piece of flat plate flame-cut to approximate size and about $\frac{3}{4}$ in. thick is suitable.

While socket headed screws are desirable for many installations and are applicable for this device, the recesses for the key soon become clogged with filings, and thus time is spent cleaning them before any adjustment is possible. Hexagon bolts are therefore preferable as they allow the immediate use of a spanner, but the corners soon become rounded and render the heads unusable. To overcome this and ensure a true permanent hexagon, case-hardening is essential, or if only occasional use is made of the spanner then cyanide hardening is useful and assists in preserving the corners.



Swivelling vice built up from scrap. Installed on the end of a bench provides more room for filing or assembling awkward jobs

An important point is the rigidity of the various details. If the shafts are made too flimsy or the bearings too short, then heavy filing is impeded because there is a tendency towards juddering and the user is thus inclined to concentrate on overcoming this rather than concentrating on the work being filed.

Finishing Spherical Seatings

Spherical seat cutters of the flat blade variety seldom impart a very high degree of finish to a component and there is always the risk that severe vibration occurs if the workpiece is of thin section; thus when this style of tool began to show signs of wear it was decided to try and replace it with another design if the initial trials gave satisfactory results.

Instead of consigning the flat blade tools to the scrap box, they were re-ground and used as semi-rough cutters, the bulk of the metal being machined with the aid of a cone type tool, then the flat blade members reduced the amount of material to about 0·015 in. on the radius ready for the new tool.

This latter tool is illustrated and it meant a departure from all previous designs, but due principally to the robust characteristics of both the tool and holder, all chatter was eliminated and by slow and careful feeding the finish was of a high order.

The usual style of Morse taper is used for locating; if applied on a horizontal milling machine the provision of a tapped hole for a draw bar is essential and replaces the tang seen in this sketch. The lower part of this holder A is forked and drilled crosswise to receive the tool B and pin C.

The cutter must rotate freely in the holder, consequently the fork needs grinding to prevent undue wear and scoring if a fragment of swarf finds its way down the side of the tool, and some care is essential with the grinding to make sure that both side walls are perfectly straight. Incidentally, if the tool is used for cleaning an existing seating a slight clearance is desirable—say about 0·01 in. between the cutter and holder—to promote a degree of float and so make the tool as far as possible self-centring.

The wall of the hole in the tool is, of course, hardened and ground—normal practice with all cutting tools—and the same processes are essential for the cross pin otherwise severe wear soon renders it useless for supporting the cutter and introduces errors in the radial form. If necessary an oilway through the pin is easily provided to introduce lubricant to the bearing surfaces.

The actual size of the tool diameter is determined by calculating the dimension X shown in the sketch—a simple calculation using Pythagoras theorem gives the figure which corresponds to the radius of the cutter. Twice this dimension gives the diameter. Fig. 2 shows this clearly.

The width of the cutter is governed by the diameter of the hole at the bottom of the radius. As the sketch shows, this width is less than the hole diameter, and for a radius of about $1\frac{1}{2}$ in. a clearance of $\frac{1}{16}$ in. is

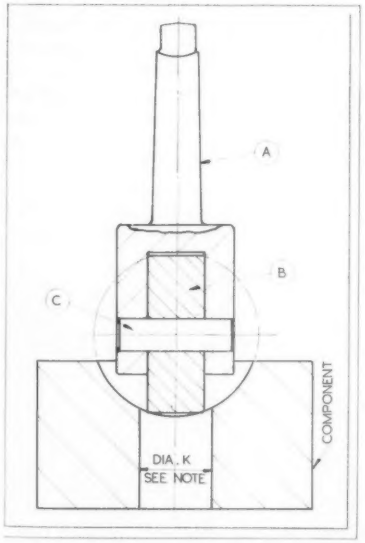


Fig. 1.—Roller type cutter showing clearance with the hole at the bottom of the seating. Note, diameter K is larger than the width of the cutter.

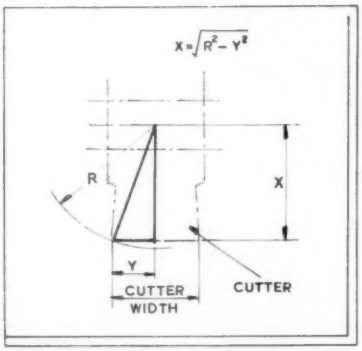


Fig. 2.—Pythagoras theorem supplies the answer to the problem of finding the cutter radius. 2X = dia of cutter; Y = half width of cutter; R = radius of special seating

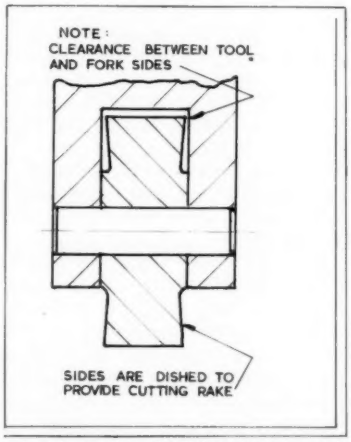


Fig. 3.—The provision of a slight 'dishing' assists the cutting action, but the sharp edges must not touch the sides of the fork in the holder

sufficient. Next the calculated diameter must be machined to the high limit of the tolerance—this is normal shop practice anyway, but as this tool has a limited amount of life it is essential to make as much use of the tolerance as possible.

Both the sides and diameter are ground, again normal practice, but the provision of a slight "dishing" of the sides introduces a rake angle and so makes cutting easier. In order to avoid the razor edge from rubbing on the side walls of the holder, this angle is made as shown in Fig. 3. A boss about 0·005 in. is enough and both sides are treated in this manner.

Despite the apparent disadvantage of the re-grinding reducing the cutter radius, this type of cutter has a surprising life—usually general repairs to the cross pin are necessary long before any real discrepancy is revealed by the tool. The speed at which to rotate the tool is approximately two thirds that required when drilling a hole of similar size.

Manganese Steel Liners for Locomotive Axleboxes and Hornblocks

The article entitled "Manganese Steel in Industry", which appeared in the December, 1958, issue of MECHANICAL WORLD contains a number of references to the various uses to which manganese steel has been put in an effort to reduce the rate of wear of machine components which come into contact either with one another, or with extraneous material whereby wear is caused.

One use to which manganese steel has been put, although not mentioned in the article referred to above, has had such spectacular results that it seems worthy of putting them on record. In the latter years of the war, one of the former main line railway companies commenced to fit manganese steel liners to the horn faces of the coupled wheel axleboxes of a numerous class of 4-6-0 mixed traffic locomotives; at the same time manganese liners were fitted to the hornblocks which form part of the locomotive frame assembly. Thus the manganese steel liner of the axlebox was mating directly to the manganese steel liner of the hornblock, the normal relative movement of one upon the other being in the region of 1¼ in. sliding movement due to the deflection of bearing springs as the locomotive traversed rail joints, crossings and deflections in the track, etc.

Previous practice in the lining of the axlebox horn faces had been to apply either white metal to them, or to peg on bronze liners. On the one hand, the white metal, which was about ⅛ in. thick, was rapidly compressed by virtue of the transfer of piston loads through the axlebox to the hornblocks, and also abraded by the action of grit thrown up from the permanent way, which grit formed a powerful abrasive material when mixed with the oil used to lubricate the axlebox working

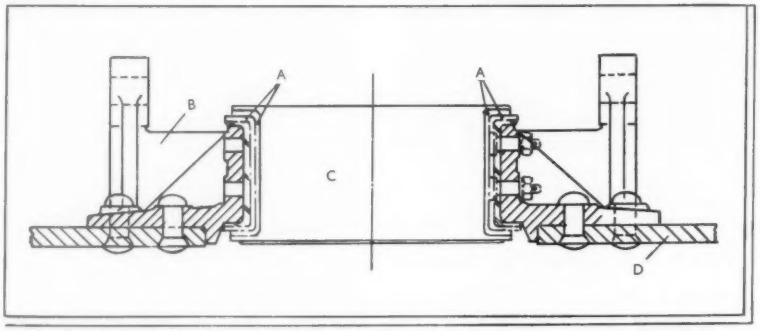


Fig. 1.—Manganese steel liners applied to locomotive axleboxes and hornblock. A, manganese steel liners; B, horn guide; C, axlebox; D, main frame of locomotive

between the horn faces. On the other hand, if bronze liners were used, the pegs which secured them to the axlebox became loose fairly quickly and were a troublesome item of maintenance. In both cases, the axlebox worked against a cast steel hornblock (or guide) which had its mating surfaces machined and ground, but not lined in any way. It was wear on these flat surfaces of axlebox and hornblock respectively which increased "knock" and caused rough riding sufficient to bring the locomotive into a main works for overhaul at mileages varying from 45,000 to 70,000 according to the topography of the particular route traversed and the loads handled.

With the fitting of manganese steel liners to both the axlebox and the hornblocks, however, the rate of growth of initial clearance between the two was very considerably slowed down, so much so that the knocking of the axleboxes in their guides no longer was the criterion which determined whether an engine required a major overhaul in the main works. Rather it was the degree of tyre wear which now became the limiting factor in reaching very high mileages between major overhauls, apart from the condition of the boiler of the locomotive, which sometimes influences this mileage on individual units.

The arrangement of manganese liners used on the axleboxes and hornblocks is shown in the accompanying plan view, Fig.1. The method of attaching the manganese steel liner to the hornblock is to interpose a machined steel liner between the manganese steel liner and the cast steel hornblock. The manganese liners for the axlebox faces are bedded and welded to the axlebox. In this way the highly polished surface of the manganese liner resulting from work hardening after a period of service can be left undisturbed when adjustment of the horn gap eventually becomes necessary, since all that is required is to replace the backing liner by one of increased thickness.

In conclusion it may be added that manganese steel liners, applied as described above, became standard practice on all types of British Railways standard locomotives, which practice has contributed a great deal to the very high mileages obtained between major overhauls with these locomotives as compared with the great majority of pre-nationalization designs. However, manganese liners had previously been fitted to certain roller bearing axleboxes in America and elsewhere, and also to both axleboxes and hornguides of some electric multiple unit stock in this country, notably on London's Underground. Speaking in 1944, the late Mr. W. S. Graff-Baker, then Chief Mechanical Engineer of the former L.P.T.B., said that after many experimental combinations of material for axlebox and hornguide linings for the bogies of electric stock, finality had been reached with a manganese steel liner for the axlebox and the hornblock since these liners virtually did not wear at all. **W.G.F.T.**

Research for Electrification

New laboratory with special provision for investigating rail adhesion and electrical problems

NEW methods of railway operation mean new problems, and on British Railways the growing momentum of the electrification programme has underlined the need for continuous investigation and research. A notable problem is that of adhesion between wheel and track of electric locomotives, and this and other problems are being investigated and solved at the Electrical Testing Laboratory set up at Willesden last year by the British Transport Commission.

Adhesion has always been a significant factor in the design of railway locomotives, even with steam traction, since a locomotive is rendered comparatively ineffective if the driving wheels slip under power. With electric traction, however, adhesion—the "limiting adhesion" being the maximum value of tractive effort which can be exerted at the rim of the driving wheels without their slipping—assumes much more importance, since, with modern electric locomotives, it is possible to obtain far greater power for the same weight. In planning the laboratory, therefore, the Commission gave urgent priority to the need for adhesion experiments.

The principal feature at present installed in the laboratory is a raised length of permanent way, 100 ft long, upon which electric traction equipment can be tested either stationary or moving slowly. Most electrically operated vehicles consist of two individual bogies, one or both of which may be used for traction, with a body resting upon them, but for most purposes it is sufficient to make measurements upon one bogie only, additional weights being used to represent the body. While any motor-bogie may be so tested in this laboratory, one bogie corresponding to the Euston–Watford stock has been permanently provided for carrying out experiments of a general nature.

In order safely to conduct the large electric currents required to the test vehicle, the vehicle's movement is controlled from a gallery. A separate supply of low-voltage d.c. power, earthed on one side, is provided by two Ward-Leonard motor-generator sets and is conveyed to the vehicle by 3rd and 4th conductor rails and picked up by shoes in the usual manner. Since the vehicle is tested only at standstill or at very slow speeds the full values of current can be provided, and the full forces and heating effects obtained, without the voltage of the conductor rail exceeding about 50 V.

In adhesion experiments, a wooden container, weighted as necessary to simulate a locomotive body, is added to the test bogie. Individual hand braking is provided for each pair of wheels. A group of knife switches, located on one side of the vehicle, enables the two motors to be isolated, or connected individually or together in series or parallel in either direction. Stationary adhesion tests are usually made with the two motors of the bogie in opposition so that the effects of torque reaction are eliminated, but slow speed tests may be made with one or both motors, the speed being limited by applying the hand brakes. Another feature of the equipment enables the track voltage to be raised up to 750 for tests involving such factors as track insulation, leakage, etc.

The laboratory is sited alongside the main L.M.R. line near Willesden Junction station in a building which formerly housed the Willesden rotary converter substation. Both the machine floor and lower floor have an area of about 4500 sq ft, most of the machine floor being visible from the wide gallery provided. The equipment includes a 10-ton hand-operated crane. The site has a direct rail connection to other main lines, is near Stonebridge Park Electrical Depot and the Willesden Motive Power Depot, and is adjacent to the existing d.c. and proposed a.c. electrification systems.

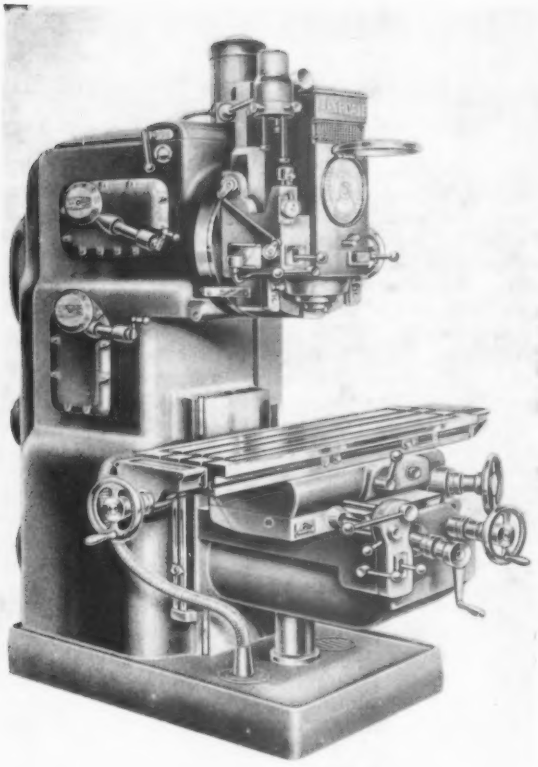
The provision of this laboratory has filled a vital gap in the study of electrically operated vehicles in service. New techniques of testing had already been developed in conjunction with the existing Mobile Testing Train, which enables locomotives or trains to be tested under exactly constant conditions of speed and power while actually running under normal conditions; but it was evident that observations taken under running conditions needed often to be supplemented by observations made under conditions of stationary or very low-speed working. The laboratory thus complements the work of the Mobile Testing Train, enabling controlled testing to be carried out on almost any form of electric traction equipment under any conditions from completely stationary in the laboratory to high speed on the line.

Although the laboratory was planned to give a high priority to the adhesion problem, the design of the installation is such that many different kinds of study can be carried out. The work can include, for instance, the measurement of forces, currents, heating, etc., in all forms of electric traction equipment from locomotives, motor coaches, lengths of track, or sections of overhead contact lines, to individual items such as motors, contactors, collector gear and insulators; all activities representing a bridge between the more theoretical conclusions of university or research department investigations and the more practical observations obtained in actual running. Space also has been left in the installation for items whose need can be envisaged in the near future, such as a transformer and rectifiers for providing supplies of a.c. or rectified d.c. power, a motor test bed with automatic controls, or a rack for testing control gear.

The Electrical Testing Laboratory at Willesden, which is part of the organization of the Chief Electrical Engineer, British Railways Central Services, does, in fact, represent a first phase in arrangements for testing which will be increasingly needed as the first sections of new electrification come into service.

Underground Gasification

The small quantities of gas produced at the National Coal Board's underground gasification site, which have been used to help generate electricity in the Central Electricity Generating Board's temporary pilot power station at Newman Spinney, near Chesterfield, do not justify further expenditure and the board have decided to terminate their development contract with Messrs. Humphreys and Glasgow and the production of gas and electricity on the site will cease in the early summer.



Archdale No. 2 high speed vertical milling machine

High Speed Vertical Miller with All-frontal Control

A noteworthy feature of the latest Archdale vertical milling machine, their No. 2 size is the provision of complete frontal control of the spindle head. The machine has been designed to meet the demand for high spindle speeds with commensurate power, and in addition to milling to exceptionally high standards of finish, it covers a wide range of work including die-sinking, toolroom and production milling. The cutting capacity of the machine lies generally in the range between $\frac{5}{32}$ in. dia slot drills which it will drive safely at traverses 50% above maker's schedule, to tungsten carbide cutters 7 in. dia, which if used in conjunction with the technique of honing in position will produce finishes equal to surface grinding.

Spindle and drive

The basic principle governing the design of the spindle head lies in the reduction of the number of gear lines between the motor and the spindle thus reducing gear contacts to prevent intermittent action of the cutter due to accumulated backlash. Thus a major factor in the spindle drive is the use of a two-speed motor to provide a wide range of speeds with only two spur gear contacts in addition to the final spiral bevel gear on the spindle. The motor is continuously rated at 4/8 hp giving synchronous speeds of 1000 and 3000 rpm respectively. To further reduce clearance in the drive, the two horizontal sliding gear shafts and the sliding vertical spindle are each provided with two opposed hardened and ground keys, hardened ground shafts, and each gear has honed keyways.

There are only two lines in the drive (apart from the spindle line), and these can be produced with extreme accuracy for centre distance and parallelism, permitting the use of profile ground gears with a minimum backlash. The final drive to the spiral bevel shaft for the four highest in each range of 12 speeds, is by wide constant mesh single helical gears. Additionally, the pulley is run at 1800 rpm in the upper range speeds to produce momentum in the gears which dispenses with the necessity for a flywheel when using carbide cutters.

The spindle head is a self-contained unit incorporating its own feeds and rapid traverse to the spindle slide. The drive is taken from the two-speed motor by Power Grip belt to the driven pulley, which connects to the spindle gear train by a single dry plate Ferodo lined electro-magnetic clutch and brake, with a rated capacity of 18 hp at 1800 rpm. The clutch control is by a lever at the front of the spindle head, positioned positively by spring loading in the "off" position.

The head swivels 90° each way, and is locked by four nuts accessible at the front. A similar hexagon headed shaft also at the front is used for swivelling the block. The angle of inclination can either be read off divisions on the swivel head or off the Clinometer scale. The design of the spindle drive ensures that the offset of the cutter when the head is swivelled, is kept to a minimum.

Gear changing is by a single crank situated in a forward position, and is facilitated by a switch which gives a momentary impulse to the clutch as the gears are about to re-engage. From the feed gears in the column universal joints are used to transmit the drive to the knee. Each joint consists of drop forged spiders carrying four ball bearings. These are mounted on shafts totally enclosed, and continuously lubricated. Prolonged tests show that these joints are completely satisfactory. Advantages of this type of drive are firstly, the common drive source for spindle and feed, and secondly, a simplified type of knee is possible with solid flat top and deep V's, producing correct alignments and easy operation.

Knee unit

The lock between the knee and the column and the locking handle for the cross traverse motion, are at the front of the knee, and both are interlocked with the selector lever. The table is of the platform type and is provided with interlock to prevent table traverse being engaged. The table, cross and vertical spindle traverse screws are provided with twin nuts with backlash elimination. A device to cut out the magnetic clutch should an obstruction occur between the rear of the saddle and the knee flange, protects the cross feed mechanism.

Besides the normal table feed trip dogs, dogs are supplied which trip and lock out rapid traverse until the completion of the work stroke to give a safe means of "quick run-up" to the work. The self de-clutching hand levers and wheels are mounted on ball races which permit instant single handed engagement and are non-spinning on engagement of feeds and rapid traverse. The electrical panel is on the right hand side of the machine 3 ft from the floor, to aid servicing.

The machine, built by James Archdale & Company Limited, Ledsam Street, Birmingham 16, is marketed by Alfred Herbert Limited, Coventry, their sole selling agents.

Friction Material Research

Methods and equipment at the new Ferodo Research Centre

THE demands made upon brake linings have increased in number and intensity during the 61 years of existence of Ferodo Limited. Where at the beginning of the century friction wear, and heat resistance were the only serious requirements, to these today are now added oil resistance, fade resistance, freedom from noise, water resistance, strength, "drum kindness" and bondability. To elaborate this list, modern friction lining for automotive use must possess a stable coefficient of friction which remains constant during mountain descents, after immersion in a ford or standing out through a wet night. It must be durable, and avoid scoring or heat-spotting the metal surface of the brake drum. It should not smell after prolonged periods of hard work, nor should it groan or squeal. It must be strong enough to resist riveting, even when the rivet holes are extremely close to the lining edge, or, when the lining is to be bonded to the brake shoe, it must be compatible with the bonding adhesive. It must be capable of being made into hundreds, sometimes thousands, of sizes and shapes and in large quantities at reasonable cost. It must be capable of withstanding leakages of hydraulic brake fluid from the brake cylinders or oil from the back axle or grease from the wheel bearings. It must function satisfactorily in the winter cold of the Arctic and be capable of storage for months in the tropics without becoming brittle. Typical figures for the peak on the linings of a family car, measured in terms of brake horse power per sq in. of lining, were 0·3 in 1900, had advanced to 1 in 1910, 2·3 in 1930, and are now 5·2. Within the near future, with the introduction of a disc-braked family car, it can be expected to rise to the region of 9 bhp/sq in.

Not only have these duties been increased because cars have become faster, with improved acceleration; they have been further augmented by streamlining, which shrouds the brakes and thus takes them out of a cooling wind stream, and by the tendency for cars to have smaller wheels. The availability of friction materials able to withstand progressively more strenuous conditions has always kept pace with the demands of every advance in engineering design and the aim of the new elaborately equipped Ferodo laboratories at Chapel-en-le-Frith is to keep several steps ahead of them.

Their work is concerned in its basic aspects with answering two questions: (a) What *is* surface friction? (b) what is the structure of the raw materials of which conventional friction materials are made? On the development side it is obviously concerned with the evolution, production and evaluation of improved materials for existing and anticipated demands.

Surface friction experiments

While our knowledge of the physical and chemical processes which take place within materials is considerable, study of the surfaces of solids has been relatively limited. More is known about the particles and forces involved in the atom, about the atomic arrangement of the molecule, and about the molecular arrangement forming the solid, than is known about the effects arising at the boundary of the solid.

A group of physicists is, therefore, studying the nature of surface friction as an abstract problem. By examining the phenomenon of rubbing between various surfaces (for example glass and indium) which in themselves have no obvious connexion with brakes, they hope to throw new light on the nature of rubbing friction between metallic and non-metallic surfaces. What happens at the contact area, and how is this changed under varying loads? What temperatures are reached during sliding? What are the relationships of associated phenomena, for example friction and wear, surface roughness and wear, surface roughness and friction? How are wear particles formed, and what chemical and physical changes have they undergone?

These are basic questions, and much of the original work in this field is being carried out in the Ferodo laboratories. It has already given some guidance on the type of materials required for particular friction and wear characteristics. It will be pursued in the years which lie ahead, for a fundamental understanding of all the factors involved in surface friction would undoubtedly revolutionize our whole approach to brake lining manufacture.

Asbestos structure

The raw materials for conventional friction materials are asbestos, resin and certain modifying agents. Of these, asbestos is the most important. It was the decision, in 1908, to use woven asbestos, spun on brass wire to increase its strength, instead of a cotton fabric base, which proved to be the turning point in the company's early history. Asbestos is an inorganic fibrous mineral. In its long fibre form it is spun and woven into cloth and is the basis of "woven" brake linings. In its short fibre form it is the basis of "moulded" linings. It is an important constituent of friction materials since, as a mineral, it does not burn. It thus combines the heat resistance of a mineral with the strength and flexibility of a fibre.

White or chrysotile asbestos is by far the most important variety and comprises 80–90 per cent of the asbestos consumed in industry (its fibres impart strength to brake linings). It is a hydrated silicate of magnesium corresponding approximately to the formula $Mg_3Si_2O_5(OH)_4$. It is mined principally in Canada and Africa. In the crude rock form, the mineral usually has a dark green lustre, but, when opened, the fibres appear white. Individual chrysotile asbestos fibres are silky and very flexible with a diameter smaller than that of any synthetic fibre.

The reason for the fibrous character of other kinds of asbestos has been known for over 25 years—the atoms of which they are composed are joined together in long chain molecules, the chains running the length of the

fibre. Since there is little cross-linking between chains, the material splits easily into fibres. Such information can be obtained by X-ray crystallography. In this technique a very fine beam of X-rays is directed at the fibre to be studied, and scattered rays are produced. These are recorded on a photographic film, and from the directions and intensities (measured on a micro-densitometer) of the scattered rays it is possible to deduce how the atoms are arranged in the fibre. Early attempts to apply this technique to investigating the arrangement of the atoms in chrysotile asbestos were either unsuccessful or gave only incomplete results.

Electron microscope photographs, which give a very high magnification, show that chrysotile fibres look like semi-transparent hollow tubes. Extensive work in the Ferodo laboratories has now shown that the X-ray patterns produced by the fibres can be interpreted on the assumption that these hollow tubes consist of cylindrical layers of atoms stacked one inside the other. In the average fibre there are about ten such layers, the outermost layer being about one millionth of an inch in diameter and the innermost layer rather less than half. This interpretation of X-ray photographs involves complicated mathematics. If it is too complicated an optical analogue is used.

Research into the structure of asbestos is conducted in parallel with other investigations of its properties. We now know that there are various ways in which the successive layers may be stacked within one another when the fibres are formed, and the proportions of the fibres with the different stacking arrangements are different in the asbestos from different mines. We now know also that there are various ways in which the layers may be rolled up, based on circular helical and spiral cylinders. Evidence suggests that the hollow fibres are often "stuffed" with ribbons of the same structure. The X-ray method is also beginning to reveal the nature of some of the impurities in asbestos.

Up to a temperature of approximately 500° C, chrysotile asbestos undergoes no physical or chemical change; above that temperature it begins to lose its chemically-combined water and gradually becomes brittle. It is, on the other hand, remarkably resistant to fusion and retains its fibrous nature at temperatures up to 1400° C.

Resin chemistry

Resins are used to bond together the constituents of a brake lining and give it the necessary physical properties. Basically the resins employed in friction materials are the phenol-formaldehyde type, which are more familiar as the basis of Bakelite plastics from which door handles and telephone instruments are moulded. When phenol is combined with formaldehyde and subjected to heat and pressure a chemical transformation takes place known as polymerization, which results in the formation of a hard resin. The resin is thermosetting, which means that, once it is polymerized, or "cured", the application of heat will not affect its chemical and physical properties until temperatures well above the curing temperature have been attained.

In resin chemistry, precise analysis of the phenols available is fundamental. Hence the importance in this work of chromatography, a simple modern way of separating a complex mixture. It is passed through a column packed with an adsorbent on which the different constituents are retained to be later washed out one by one. Coloured constituents form coloured zones as they descend the column; colourless ones may become visible in ultra-violet light. As each zone emerges it is collected in a separate tube. Evaporating the solvent leaves one constituent of the original mixture.

The molecular structure of these constituents can be inferred from knowledge of their molecular weights (measured by their effects on the boiling point of a solvent) and from infra-red spectra, which suggest possible molecular structures for these different fractions which are consistent with their differing reactivities. An infra-red spectrometer contains a prism of common salt which splits up the invisible infra-red radiation into a spectrum. The energy at each point of the spectrum is detected and amplified, and a graph of it drawn automatically. Different substances absorb the energy in different parts of the spectrum, and so can be analysed qualitatively and quantitatively by their spectra.

Deliberate variation of the resin formula and of the proportions of resin to other ingredients will affect the characteristics of the final product considerably. New synthetic resins must also be evolved with one eye on the complexities of large scale factory production. For example, a resin with a critical cure time might be difficult to control under factory conditions.

The original method of making a resin involved distillation to remove water and was satisfactory for simple resins. Some new resins with improved properties were difficult to make in this way. They thickened up so much that they cured before the water was removed. The difficulty was overcome by dissolving the resin in a solvent, which distils with the water but separates and returns to the resin.

Small variations in conditions tend to "snowball" during the process, so after distillation the resin is "matured" till it has the desired properties. The end of the maturing process is decided on the basis of viscosity and cure time tests. For the viscosity test a falling sphere viscometer is used, the operator measuring the time a sphere drops through a given distance in a solution of the resin. The cure time may be measured by stirring the resin in a constant-temperature bath of hot glycerol and observing the point at which it hardens.

The evolution of a lining

Deciding what ingredients shall go into a brake lining is usually the joint concern of chemist and physicist, the one considering primarily the content and processing, the other friction and general physical properties. In most cases the starting point is information, either supplied by a customer or gathered by Ferodo technologists, about the level of friction required, temperatures and speeds involved, mating surfaces, the braking system, and other factors having a bearing on the lining's behaviour. From past experience and with the information obtained by the research chemist and physicists, a tentative idea is obtained of the type of material required and the ingredients necessary to produce it. Small sample batches are then made up, some varying the proportions of raw materials, others the methods of processing. Detailed records are kept of all these variations.

When fully processed, the prototype linings are subjected to a series of frictional and other physical tests designed to reveal the strong points and weaknesses of each. In one test, for example, a sample of the new friction material is inserted between the plates of a machine

on which friction and wear are investigated. The lower plate, to which the sample is clamped, is rotated against the upper plate, the torque on which is a measure of the sample's coefficient of friction. Wear can be assessed by weighing and measuring the samples, before and after test. Another test determines the suitablility of the material for bonding purposes by subjecting a bonded lining to progressively greater loads and measuring the load at which the bond between the material and the metal shoe to which it is bonded breaks down.

As a result of such findings, further sample batches are prepared, with modifications in the resin content, mixing procedures, resin curing times, or any other factors which the tests of the first batch have shown to be necessary. Eventually, when the material's performance matches the original specification and a final process has been established, the development or adaptation of methods to produce it on a factory scale can get under way as well as consideration being given to submitting the material to a potential customer for test.

The Ferodo test house

After a new experimental lining has been processed, it is most important that it should be tested under conditions closely simulating those it will encounter in service. For example, in developing a lining for racing purposes, high rubbing speeds must be used; the duties to be simulated for private cars, trucks, buses, aircraft and industrial applications generally differ considerably from each other. Since it is not practicable nor necessarily desirable to test all experimental linings on the road, test machines are employed. They are not only used as a filter to reject for road testing materials that do not show considerable promise, but possess the advantage that the conditions of test can be strictly controlled.

Machine-testing speeds development by eliminating many time-wasting factors. Cooling can be accelerated by fans, so that more brake applications can be made in a given time without over-heating the brakes. Automatic controls enable the machines to work day and night without the need for a large team of drivers.

The machines used are inertia test dynamometers so proportioned that a complete brake can be mounted for test. They consist basically of a driving motor, coupled to a shaft carrying a bank of flywheels. The brake drum is mounted on one end of the shaft while the brake back plate and shoe assembly is attached to a torque reaction member mounted in line with the shaft, the torque loads imposed on it being indicated and/or recorded. The brake reaction shaft is mounted so that it can slide back to allow the brake to be withdrawn from the drum for examination.

One flywheel is keyed to the shaft and thus always revolves with the brake drum. All the other flywheels are mounted on bearings on the shaft and are free to remain stationary when the shaft revolves; or to be coupled to the fixed wheel. By using different numbers of flywheels the inertia of the machine can be adjusted to give approximately the kinetic energy at the appropriate shaft speed to simulate the conditions obtained on the vehicle.

In a test the flywheels are accelerated by the driving motor until the brake drum reaches a speed corresponding to the desired road speed of the vehicle. Then the motor is declutched or shut down and the brake applied to bring the machine to a standstill. A complete test will consist of groups of between 30 and 100 such stops, with cooling periods between the groups.

In the Ferodo test house there are a number of these inertia test dynamometers, and the house is designed to accommodate future expansion should that prove necessary. The larger machines are engaged on aircraft, heavy transport, railway and industrial brakes; the smaller on development for cars, motor cycles and pedal cycles. Clutch machines cater for testing car and motor cycle clutch facings. One machine, which tests linings immersed in oil, is of value in the development of linings for automatic gear boxes. They are not merely employed to evaluate new formulations: a check is also kept on factory production, and facilities are also available for testing brakes themselves, as distinct from linings, on behalf of manufacturers.

A typical control panel can operate a machine automatically at a number of speeds, time cycles, braking torques, cooling settings and times, all pre-selected over a sequence of 2500 brakings. The latest panels are fitted with a triple dekatron counter, which automatically indicates braking times up to 10 sec to the nearest 1/100 sec, relieving the operator of stop watch tripping and making for greater accuracy.

Such apparatus is designed and built by an electronics section, working closely with a machine control section, both under the test house manager. The former also makes and fits the thermocouples which measure the working temperatures of brake linings on test machines and vehicles. Strain and capacitance gauge work and electrical instruments in general also come within its orbit.

The types of machine can be divided into constant torque and constant pressure inertia machines. Automatic constant torque inertia machines test lining material under standard conditions. It may happen that when a brake is applied the heat and pressure generated on the surface of the lining cause the cofficient of friction to vary during the stop, usually to a lower value. This type of machine automatically adjusts the pressure up or down to compensate for any fluctuation in friction coefficient. Any self-servo pressure from the brake shoe is also compensated. Thus linings are tested at a constant rate of energy dissipation, the brake operates at constant torque, and all materials on the same test reach the same temperature, which is particularly desirable for comparison purposes.

The constant pressure machines cover four inertia ranges. They normally operate at constant pressure applied to the lining, but owing to the variation in friction coefficient and self-servo pressure, the brake torque is not constant. When automatic torque control is required, however, this can be selected on one of the small inertia machines. The largest of these machines can store over 16 million foot pounds in its flywheels.

A complete cycle of machine tests on a brake lining may reveal certain faults, for example, variation in the coefficient of friction during each individual brake application, reduced friction level after fade, effect of temperature upon friction, undesirable speed/friction characteristics, inadequate resistance to moderate or severe fade conditions, severe over-recovery from fade, or delayed fade. The wear of the brake lining can be assessed either on the basis of the weight loss or by the reduction in thickness during the test, as measured by a micrometer. It is generally desirable to measure both these

values, because the amount of material removed is very small and one method of measurement serves as a check on the accuracy of the other.

Clutch wear

Clutch facings are tested on machines which simulate both normal engagement and slip at full torque. The former type consists of two flywheels mounted on a common shaft to which two standard 10-in. clutches are bolted. A motor drives the spinner of the right-hand clutch while that of the left-hand clutch is held fixed to the frame. The twelve second cycle, which is auto-controlled, consist of spinning the assembly up to motor speed by engaging the first clutch. This is then released and the second let in to brake the assembly to rest. Apart from a small amount of energy absorbed by the bearings, the two clutches do the same amount of work, one by acceleration and the other by braking. From this test the wear rate of a facing after 10,000 cycles is obtained. The friction of the facings is also measured at intervals throughout the test.

The slip test machine consists simply of a motor driving a standard flywheel assembly. The motor is run with the clutch fully engaged and the spinner held fixed by a lever, piston and oil pressure. As the clutch spring pressure is calibrated before each test, the oil pressure, which is recorded, is a measure of friction coefficient.

A clutch bursting machine determines the rotational speed at which centrifugal forces cause a disc facing to fly apart at clutch housing temperatures. The disc, clipped to a face plate, is mounted on a shaft inside a safety chamber which is heated at controlled temperature. The shaft is spun by a variable speed motor and step-up drive and can reach some 25,000 rpm. Usually, however, discs disintegrate before 19,000 rpm.

Powder metallurgy techniques for friction materials

Until recently conventional friction materials, based on asbestos, fulfilled all the demands made upon them for the control and transmission of power. Much modern earth-moving equipment, however, depends on clutches which must sustain duties beyond the scope of conventional linings and facings, and a similar problem faces the designers of tractor clutches, automatic gear boxes for road and rail vehicles, and lock-up clutches for the torque convertors used in rail car propulsion. Alternative materials are required capable of retaining their strength and performance at the high temperatures produced in heavy duty applications.

Cast or wrought metals have the requisite strength but have quite unsuitable friction and wear properties. A solution to the problem has been found in composite materials produced by powder metallurgy. Sintered friction linings, as they are called, consist of mineral fillers distributed throughout a metallic matrix. The component powders are mixed conventionally and compacted to a tractable form in high tonnage presses. Since the friction facings are often large and thin, accurate dispensing of the mixed powders into the die (or mould) cavity is extremely important. Compacted density is controlled by the shape, size and apparent density of individual powders. Increase in density and bonding to a supporting member is effected by pressure sintering at red heat, a reducing atmosphere being maintained around the parts during sintering to assist in densification and bonding.

Sintering may be defined as the bonding together of metallic particles at a temperature lower than their melting point. The driving force in sintering is surface tension, the principal mode of material transport being viscous flow. The area of contact between particles grows as the sintering time is extended, and voids or "pores" between particles are removed during the densification process.

Research on sintered metal linings is concerned both with components and with their processing. It begins with the analysis of particle size distribution, which is conducted by the Ro-tap sieve method, sedimentation balance weighing and microscopic counting, in which representative samples of powder are compared directly with special eye piece graticules. At the same time, another group is at work on improved methods of compacting, handling and sintering the powders. For example, the radius forming of sintered friction materials is an important field of development at present.

Cermetallic materials

The introduction of a metallic phase into a ceramic body improves its ease of fabrication and mechanical properties. Compared with sintered metal linings, cermetallic friction materials have increased heat and wear resistance and a higher friction level. Research work on cermetallics is being directed principally to improved methods of fabrication. The basic method of manufacture is to mill the component metal and ceramic powder and to compact and sinter them at high temperature.

Experimental production laboratory

The development of new friction materials does not stop at experimental manufacture in a laboratory. Before full-scale production can begin, a great deal of work remains to be done to translate laboratory techniques into factory processes. An experimental production laboratory is, therefore, an essential part of the Research Centre. It contains more than a hundred machines, both standard factory equipment and prototype plant for new or improved processes. Under the close supervision of chemists, development engineers and factory technologists, methods are worked out for producing the new material in bulk, taking great care to ensure that the quality of the original experimental samples is maintained.

When moulded materials are being produced, careful attention has to be paid to the mixing of the raw materials, establishing the most suitable moulding techniques, investigating methods of curing, and establishing finishing techniques. Woven material production, on the other hand, raises such problems as the manipulation of the fabric and the technique of impregnation.

Any of these factors can vitally affect the quality of the finished product. Constant checks are, therefore, made to establish the effects of changes in technique on the chemical, frictional and other physical properties of the finished product.

The whole aim of the experimental production laboratory is to evolve methods of manufacturing friction materials which are as economical and efficient as possible. It is not concerned only with new products; a substantial part of its efforts is devoted to the general improvement of manufacturing methods. This means that Ferodo engineers have to develop plant of unique design, because the demands of friction material manufacture are often too specialized to be met by standard equipment.

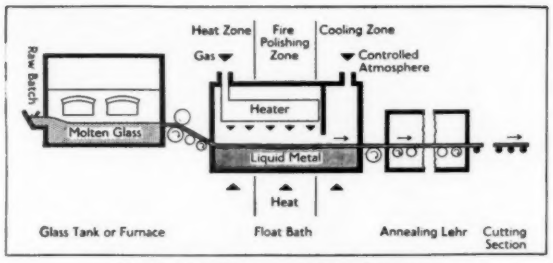
Float Glass—Combining the Merits of Sheet and Plate Glass

After nearly seven years of intensive work an entirely new method of making flat glass has been developed by Pilkington Brothers Limited at St. Helens, Lancashire. The process which is fully patented they have called the Float process and the resulting product, Float glass combines the best qualities of both plate and sheet glass.

The essential point of the Float process is a continuous ribbon of glass floating on a bath of molten metal so that the glass emerges with a brilliant natural or so-called "fire finish" which eliminates the need for grinding required in the manufacture of plate glass.

Hitherto only sheet glass has possessed a fire finish which results from drawing continuous sheets of controlled width vertically from a pool of molten glass into an annealing tower. The surface of sheet glass whilst having the desired finish is not absolutely flat or free from distortion, the weight of the rising glass and its clinging viscosity cause ripples and stretching before it has cooled enough to be safely solid.

In the plate glass process a continuous ribbon is formed by passing glass at 1,100° C through a pair of water-cooled rollers. After annealing in the lehr, the ribbon is passed through a number of twin grinding heads which grind and polish both surfaces of the glass simultaneously.



Simplified flow diagram of the Float glass process

The plant for float glass production is shown in Fig. 1. Molten glass from the furnace flows into the float bath where liquid metal provides a dead flat supporting surface for the glass. Heat is applied above and below to produce the brilliant fire finish and the ribbon is pulled out across the bath and gradually cooled and hardened sufficiently to permit handling through the lehr.

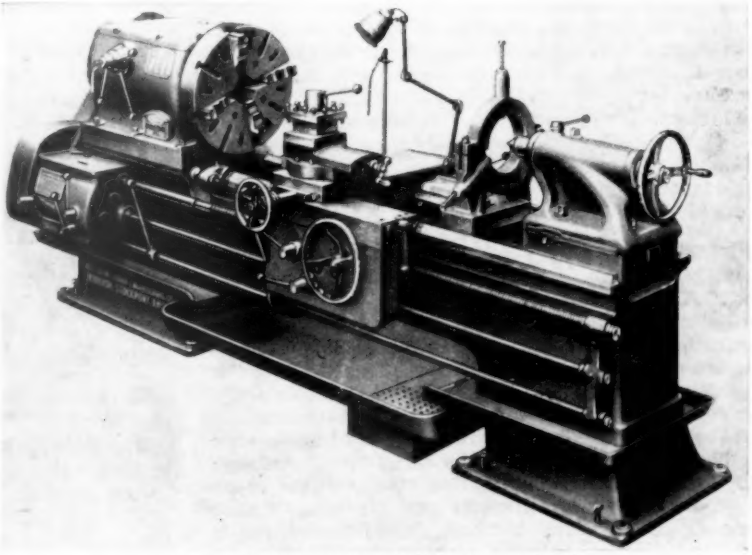
At present float glass is in full scale production up to 100 in. wide, but initially sales are confined to the motor industry.

Heavy Duty 10½ in. Centre Lathe

In succession to their 10½ in. M.D. centre lathe which The Crowthorn Engineering Company Limited, Atlas Works, Reddish, Stockport, have been manufacturing for a number of years, they have now introduced the 10½ in. H.D. lathe. The salient features of the new model are the increase in spindle bore to 3⅝ in., a redesigned bed accommodating a larger gap of 36 in. swing × 15½ in. width and increased power in the headstock.

The bed is of heavily ribbed construction, of ample width and depth, with diagonal bracing to ensure the utmost rigidity. Either straight or gap beds can be supplied, the latter having a removable gap piece. The redesigned headstock provides a range of 12 spindle speeds which are obtained by a centralized gear change control. The normal speed range available is 10½ to 302 rpm but higher ranges of 16 to 453, 21 to 604 can be provided if required.

The spindle is machined from a solid steel forging and is mounted on twin opposed pre-loaded Timken taper roller bearings. The rear end is carried on a parallel roller bearing to accommodate any expansion of the spindle. A patent multi-plate friction clutch incorporated in the V-driving pulley is controlled by a lever at the headstock end and also by an auxiliary lever at the side of the apron. The clutch lever also operates a brake.

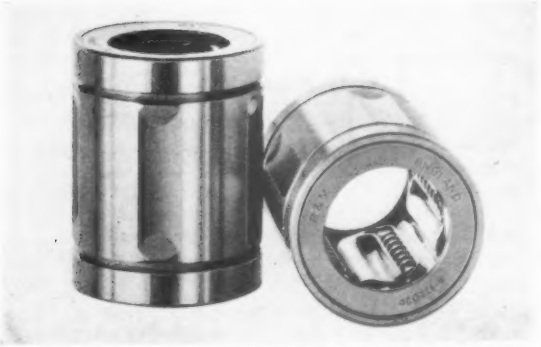


Crowthorn 10½ in. centre lathe with 21 in. swing over the bed

The quick-change gearbox of the Norton type box gives a screwcutting range of 40 different threads and 40 changes of feed without the use of loose gears. A quadrant plate can be fitted to take change wheels for metric, diametral, module and other special threads. A lever on top of the gearbox provides reversing mechanism for both feed and screwcutting motions.

The tailstock has been entirely redesigned to reduce friction to a minimum. The barrel is bored No. 5 Morse taper and a revolving centre can be provided as extra equipment. There is provision for lateral adjustment for machining slight tapers.

The motor drive is neatly arranged at the rear of the lathe, the 8 hp 1C00 rpm motor being mounted on slide rails for easy adjustment of the V-drive. The motorized suds pump which is push-button controlled from the headstock is a standard fitting on this model.



The recirculating ball tracks are plainly visible in the bore of the Ransome & Marles ball bushing

Ball Bushings for Precision Linear Motion

Ball bushings, already widely used in U.S.A. are now being manufactured in this country by Ransome & Marles Bearing Company Limited, Newark-on-Trent. Designed for precision linear motion, the bushings contain three or more ball circuits or retaining tracks around which the balls recirculate as in a conventional ball bearing. Each bushing forms a compact assembly which can be handled as a unit and is made as easy to fit as a plain bearing. Eleven shaft sizes range from $\frac{1}{4}$ to 4 in. dia have corresponding outside shell diameters from $\frac{1}{2}$ to 6 in., which are grooved to provide endwise location.

Obviously their application is limitless, and where sliding motion is a necessary function of a design these bushings will provide linear rotary motion with its attendant advantages of low friction co-efficient and reduced wear.

Overcoming Cutting Edge Breakdown—A New Carbide Tip

An inherent characteristic of carbide tips is that brittleness increases with hardness; thus there is a tendency for tools to fracture rather than to wear when conditions of use are not appropriate. Research into this problem has been conducted jointly by The British Thomson-Houston Company Limited, Rugby, who manufacture Ardoloy, and Alfred Herbert Limited, Coventry, with the object of producing a grade of carbide having a better balance between hardness and brittleness and has resulted in the standardization of a new grade of Ardoloy known as AK.

The constituents of Grade AK are processed by an entirely new technique, resulting in composition and grain structure having a virtual immunity to chipping of the cutting edge.

The toughness of Grade AK is claimed to be its most remarkable feature, which permits continuous heavy metal removal usually limited only by the capacity of the machine to traverse the tool at coarse feeds and great depth of cut, using medium to low speeds.

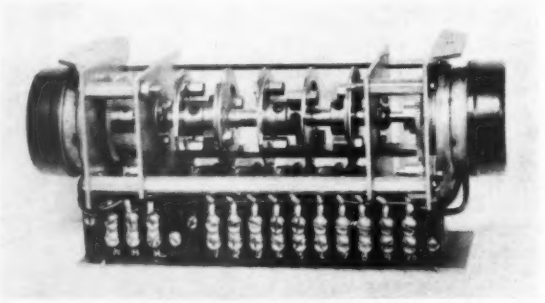
These advantages are most impressive on heavy planing, boring, plano-milling and similar operations where it is desirable that the cutting tool should not be the limiting factor in the rate of metal removal.

Whilst the properties of Grade AK will be more evident in heavy roughing operations on steel components, the material is versatile. A cutting speed range of 150 to 250 fpm on steel is recommended, but this range can be extended for operating at speeds as low as 80 and up to 350 fpm. The depth of cut, feed and speed can be determined to suit the power available. Cuts of over 1 in. deep and feeds of 0·060 in. per rev are well within its capacity, though a better performance under suitable conditions is obtained with an $\frac{1}{8}$ in. depth of cut and feeds of 0·005 to 0·010 in. per rev.

Reversible Sequence Controller

A synchronous multi-circuit timer which can be driven in either direction, has been developed by The Rodene Electrical Company Limited. The effect is achieved by fitting two Rodene self-clutching motors so that when one is energized it automatically clutches on to the camshaft and drives it in one direction unimpeded by the other motor which remains unclutched. Similarly energizing the second motor drives the camshaft in the reverse direction. The unit can have up to 24 fully adjustable twin cams, and was first produced to raise and lower the output of a set of pumps. It is also made with the two motors at one end (one being shaded to give reverse rotation), and with a variable resistor fitted to the free end of the camshaft which can be connected to re-balance a bridge when the correct number of heaters, pumps or the like have been switched on to give the rate of correction called for by the condition that unbalanced the bridge.

The illustration shows a unit less the cover which is normally of metal but which can be of non-inflammable transparent plastic. A dial showing the position of the camshaft can also be fitted. The sole distributors for Rodene products are D. Robinson & Company, 717 London Road, Hounslow, Middlesex.



Rodene synchronous multi-circuit timer

Producing $\frac{1}{4}$ Micron Size MoS_2 Flakes by Flotation

The emergence of molybdenum disulphide as a solid lubricant capable of withstanding pressures of $\frac{1}{2}$ million psi and over, and of operating in high temperatures has been an outstanding development during the past few years. However, the particle size reduction of MoS_2 has always been a difficult undertaking and ordinary milling and similar processes are ruled out as they cause oxidation of the material leading to the formation of molybdenum trioxide which has no lubrication characteristics.

The finest powders generally obtainable have average particle sizes of $\frac{3}{4}$ micron to 3 micron. It is possible to reduce MoS_2 particles in liquids, in ball or roller mills. It is, however, often found that such quasi-colloidal

dispersions are not as effective as the flake materials. There appears to be a loss of some of the advantageous properties of MoS_2 possibly also due to oxidation.

K. S. Paul (Molybdenum Disulphides) Limited

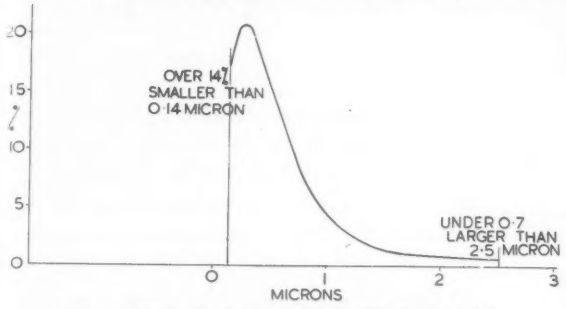


Fig. 1.—Diagram showing the particle size distribution of MoS_2

Great Western Trading Estate, Park Royal Road, London NW10, have now produced on a commercial scale by means of a quasi air flotation method a molybdenum disulphide powder of average particle size of $\frac{1}{4}$ micron to $\frac{1}{2}$ micron. Trial production batches have shown considerable consistency of results. Fig. 1 shows the particle size distribution of this new Moly-Paul superfine powder (which incidentally is the company's 9th powder). It will be seen that distribution is over 65% under $\frac{1}{2}$ micron particle size.

Fig. 2 shows that the flake-like structure of the molybdenum disulphide has been maintained. Most important, however, the change in pH value was not detectable as compared with standard and micronated particle size materials.

Crane-approach Warning System

Where two or more overhead travelling cranes are operating on the same track there arises a constant danger of collision, because the crane driver concentrates on his load and the signals of his slinger rather than on the movement of neighbouring cranes. To eliminate this danger a new electronic equipment has been developed (under the auspices of the British Iron and Steel Federation) by The British Thomson-Houston Company, Rugby. The equipment, the first of its kind to go into service in a British factory, is undergoing extensive trials at the Redbourn, Scunthorpe, iron and steelworks of Richard Thomas and Baldwins Limited.

The BTH system is based fundamentally on the principle of the echo sounder. An oscillator circuit generates short electrical pulses at regular intervals which are emitted in the form of very high frequency sound, inaudible to the human ear, by a loudspeaker fitted on the crane. The sound pulses are reflected by a special trihedral reflector fitted on the neighbouring crane and the echo is picked up by a microphone mounted alongside the sound source. The microphone signal is then amplified and fed to relays which may operate audible alarm or visual indicating circuits in the driver's cab, or may be used to initiate automatic braking of the crane. Automatic warning of approach can thus be given to one or more cranes operating on the same track, or to cranes operating at different levels.

An important feature of the equipment is that the protection system can be made to operate at any desired position on the crane track merely by placing a trihedral reflector in the path of the sonic beam. Overrunning at

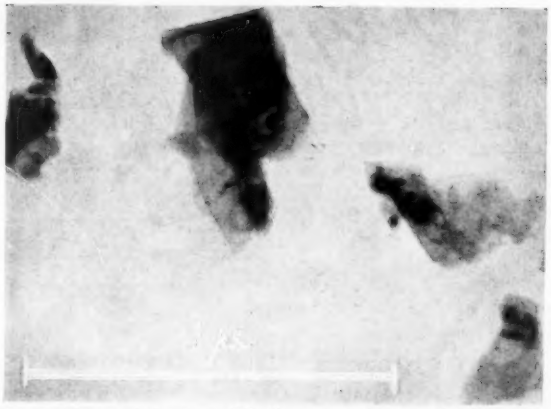


Fig. 2.—Micrograph showing the flake-like structure of the new ultra-fine powder

end stops can thus be avoided and complete protection can be given to maintenance men working on a disabled crane, or on the crane track, for the reflectors can easily be fitted at suitable positions in the path of the working cranes.

The equipment can be adjusted to operate up to a distance of 60 ft from the reflector. The oscillating frequency is 11 kilocycles, and the time taken for a return echo to operate the protective system is 2 millisec per ft. Selective circuits are designed to make the alarm system unresponsive to any other signals than those of the genuine echo. The system is designed to operate from any d.c. crane supply.

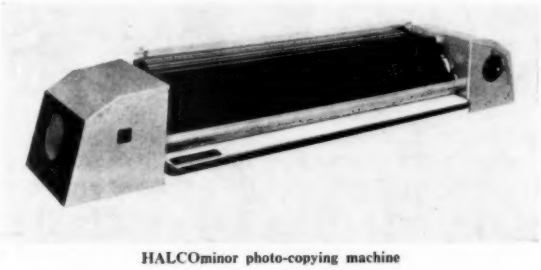
Bench-top Photo-copying Machine

Recognizing the need for a small inexpensive photo-copying machine that would handle prints up to 40 in. in width and one which could be used on top of a bench or filing cabinet, J. Halden & Company Limited, Rowsley Works, Reddish, Stockport, have produced the HALCOminor. Continuous in operation the machine is fitted with a lamp assembly comprising six 80W 5 ft fluorescent tubes and works on 200-250 volts a.c., a special starter switch being incorporated in the design. The total current consumption is 5.5 amp.

The printing speed can be varied by means of an electrical control up to a maximum of 12 ft 6 in. per minute, the maximum printing width is 44 in.

The area of bench space required is 6 ft × 1 ft.3 in. and the machine is $11\frac{1}{2}$ in. high. A synchronized semi-dry dyeline developing unit can be fitted to the machine as an extra.

The price of the HALCOminor which is finished in two-tone hammer grey stove enamel is £156 10s. or £182 if fitted with a developing unit.



HALCOminor photo-copying machine

Theory of Machines. By Bevis Brunel Low. London, 1959; Longmans, Green & Co. Limited, 25/- net (by post 26/6). 522 pp. 5½ × 8½ in.

This book, which starts with the Greek alphabet and finishes with the natural vibrations of a horizontal bar supported on two springs, contains in this third edition twenty chapters of which three, occupying between a fifth and a sixth of the book, are on vibration. This relatively large proportion in a book covering the whole ground of the theory of machines shows the importance of vibration in these days of high speed machinery. Looking at the rest of the book in the same way it is seen that balancing, governors and friction share the honours for the next important group, which again is readily understandable in the light of present-day developments. Next we come to gearing, gear trains, and belt and rope drives, but if these were taken as one power transmission subject they would move up the list. The shorter chapters are on cams and the various fundamentals.

Altogether the book is a modern text which is well suited to current needs, a conclusion supported by the bibliography which shows that the present edition is the seventh impression—evidence enough of the popularity of the book.

Applied Mechanics. By J. A. Cormack. London, 1958; Chatto & Windus Limited. 30/- net (by post 31/2). 342 pp. 5¼ × 8½ in.

Text books are used for different purposes. Firstly, they are used for training, and their user is well advised to become thoroughly familiar with the text, to the point where he can readily quote and argue from it. Secondly, they are used for reference, and a book that has been acquired in the first way is likely to be kept on hand until, and if ever, it is superseded by a more advanced treatise: on the other hand a book with which the owner is not intimately familiar is kept for reference only. Complete familiarity with an acceptable text makes the arrangement and presentation of the subject matter relatively unimportant, but a book that is easily used for reference is likely to be more acceptable in any circumstances, and because of this the book before us now is likely to attract attention. It is arranged in short articles—which in itself is not new—and each deals with a principle, a term or method; but each is a carefully presented miniature monograph which enables the reader to concentrate on and become familiar with each detail of the subject. The scope is the S3 stage for the Ordinary National Certificate and the comparable stages of professional examinations, and there is ample illustration in the text from recent examination papers.

books

Jig and Fixture Details and Units. By H. W. Hardy, London, 1959; The Machinery Publishing Company Limited. 18/6 net (by post 19/3). 172 pp. 5½×8½ in.

The important feature of this book is the tabulation of dimensions for a range of sizes of numerous jig and fixture details. Each table is accompanied by a clearly drawn sketch. The devices are collected into ten groups comprising: clamping devices; steady clamps and supports and steady and indicating pins; clamping devices for circular components; fixed and adjustable V-locators and clamps; combined centralizing and clamping devices; adjustable and compensating support pins; spring loaded latches and other devices for leaf jigs; indexing devices and slip washers, standard pad bolts, clamp nuts and the like; standard slip and liner bushes, screwed clamping bushes and control screws; and miscellaneous units. Altogether the book presents a very useful collection of standardized parts which will save much time and duplication in the tool shop as well as in the drawing office. The collection need not be adopted as it is; obviously, similar lists can be built upon the collection to suit particular needs.

Turbine Design for Aircraft Engines. By Norman C. Breddy.

Drop Forging Die Design. By R. C. Jones.

1959; Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey. 3/6 each net (by post 3/10 each). 45 and 92 pp. 5½×8¼ in.

These two new additions to the A.E.S.D. "Pamphlet" series appear in brightly coloured covers of modern design. They are both eminently practical texts which reflect the experience of the respective authors, and both contain practical worked design examples as well as a sufficient exposition of principles.

Mr. Breddy deals mainly with the axial flow type of turbine and after discussing the theory of gas flow through the machine goes on to blade design, compressibility effects and reaction and swirl. Then follows at length a worked example of a two-stage turbine designed on the free vortex theory. A shorter treatment is accorded the inward flow radial turbine as used in aircraft for providing cooling air for cabins and instruments. The metallurgical problems peculiar to gas turbines are rated and tabular information included on the Nimonic series of alloys.

Mr. Jones presents much unique information in his monograph on forging dies. Due to the peculiar nature of the process, good design is more than usually a matter of understanding the material and its behaviour when subjected to violent formation. The author conveys his insight into the intricacies of the subject clearly and convincingly. Anyone who takes up this work will of necessity have a lot to learn, but Mr. Jones has provided the reader with the means of setting him far on the road to success.

Single-phase transfer of liquefied gases.—The current method of transporting liquefied gases over distances exceeding a few hundred feet is by mobile, insulated transport vessels and the greatly increased use of liquefied gases has prompted an examination and re-evaluation of the basic problems connected with their handling in a circular which examines the feasibility of transporting liquefied gases over appreciable distances through piping systems. The problems encountered in the single-phase transfer of liquid gases are discussed in detail. A general system of equations and the empirical information required for the design of long-distance transfer systems are presented. A closed-form solution for the mathematical equations for incompressible flows is obtained and discussed. Information required for numerical computations involving helium, hydrogen, nitrogen, and oxygen is given in graphic form; the numerical solutions for three general problems involving hydrogen and oxygen are obtained. The circular is No. 596 of the series published by the U.S. National Bureau of Standards. It is by Robert B. Jacobs and is available from the U.S. Government Printing Office, Washington 25, D.C., U.S.A., price 30 cents net (by post 38 cents).

Guidance on Engineering Work for Boys.—"Engineering Work for Boys", a fully-illustrated booklet is the latest in the Central Youth Employment Executive's "Choice of Careers" series (H.M.S.O., No. 78. 1/9 net). It stresses the wide range of openings in engineering, the main branches of which are shown pictorially in a double page chart while another chart shows the main departments of a typical engineering works. One section touches on the opportunities for those with higher educational qualifications and information is given about recruitment, apprenticeship and other training, and on conditions of work and on the qualifications required for higher technical posts.

Fan test code.—Much attention is being given to the sound level fans and blowers and in the absence of an official test code Keith Blackman Limited, Mill Mead Road, Tottenham, London N17, have formulated one based upon work done in their acoustics laboratory. Issued as Publication No. 45 the code details the general basis of the test and gives details of ducting proportions for centrifugal, axial and propeller fans. Also included is a glossary of acoustical terms.

American Standards.—The 1958 edition of the "Book of ASTM Standards" will be the largest in the series, comprising ten parts, 13,600 pages and 2450 standards. Parts 1, 2 and 3 deal with metals, 4 and 5 with building materials, 6 with cellulose products (wood, paper, etc.) adhesives and leather, 7 with petroleum products and engine tests, 8 with paint, aromatics, coal, coke, gas and anti-freeze, 9 with plastics, rubber, insulation, etc., and 10 with textiles, soap, water, atmospheric analysis, and wax. Price per vol. $12 to $14.

References on Fatigue.—The American Society for Testing Materials has prepared a list of references published in 1957 dealing with fatigue of structures and materials, following the plan used in previous annual lists from 1950 to 1956. References are generally so arranged that sheets can be cut apart for filing according to any desired plan. Brief abstracts have been included when these were readily available. Copies of this publication may be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa., U.S.A., at $3.00 a copy.

New Standards

P.V.C. insulated cables for power switchgear wiring (B.S.1231:1958) Price 5/-.

In this revision of the 1945 edition the range of cables has been extended to deal with all voltages normally encountered in the small wiring of power switchgear.

Of the four types of cable now specified, type A is intended for supervisory circuits and type B which is suitable for working voltages up to 250V to earth, corresponds to the type specified in the 1945 edition. Types C and D are suitable for higher voltages such as internal connections in rectifier equipment, and in motor starter and controllers.

The quality of the insulation is now specified by reference to B.S. 2746, "P.V.C. insulation and sheath of electric cables".

Code for the continuous sampling and automatic analysis of flue gases: Indicators and Recorders (B.S. 3048:1958). Price 15/-.

Prepared at the request of the Ministry of Fuel and Power to stimulate greater combustion efficiency in industry, this new illustrated publication deals with automatic instruments which give a direct indication or record of flue gas composition.

Separate sections of the code deal with thermal conductivity instruments, instruments depending upon chemical absorption and chemical reaction, viscosity and density instruments, and gas analysis instruments of recent origin. In addition there are parts on: determination of dew point, and on kindred subjects such as dust and smoke testing, smoke density indicators and alarms, etc.

Dimensions of ball bearings and parallel-roller bearings (B.S. 292: 1958). Price 12/6.

This revised publication (65 pp., 56 illustrations) relates to those features which control the interchangeability of bearings as units; it does not deal with their internal dimensions or detailed design.

Dimensions are specified for single-row, angular contact and double-row journal bearings; for rigid, parallel-roller, journal bearings; for snap-ring type ball journal bearings; for magneto bearings, and for single-thrust bearings with flat seatings and with spherical seating rings. Inch and metric sizes are provided up to 20 in. and 150 min bore, respectively. The tolerances on the external dimensions, diametral clearance, and permissible errors due to wobble and eccentricity are specified, as are fillets and shoulder heights for metric journal bearings.

Slotted grub screws (B.S. 768:1958) Price 4/6.

Previously known as Grub screws, B.S. 768 has now been revised and published under the title "Slotted grub screws". The new edition includes requirements for screws with UNC and UNF threads, as well as B.S.W., B.S.F. and B.A. Since the standard now provides for grub screws with Unified threads, every effort has been made to ensure that the dimensions and standard types of points do not conflict with those specified in the equivalent American standard.

Split cotter pins (B.S. 1574:1958). Price 4/-.

An important step towards international standardization of practice has been taken in this revision. In common with American and continental standards, it now defines the nominal length of the pin as the distance from the underside of the eye to the extreme end of the short leg. The sizes of mild steel cotter pins in diameters from $\frac{1}{32}$ to $\frac{1}{2}$ in. listed as standard are now based on this principle and users should bear this in mind when ordering supplies to the new standard.

The revision also includes an appendix giving the metric sizes likely to be included in an ISO recommendation.

Water tube boilers and their integral superheaters (B.S. 1113:1958). Price 25/-.

Extensively revised and fully reflecting modern practice in boiler manufacture, this new publication (106 pp. 42 illustrations) completely supersedes B.S. 1113:1951.

Among the new features are the inclusion of requirements for additional steels, welded-on and welded-in tube stubs for connecting pipes and tubes by welding to headers, the butt welding of pressure parts, and for the welding of non-pressure parts to pressure parts. Modifications have been made to the formula for drum and tube thickness, the tables of design stresses for boiler shells, integral superheater drums, headers, standpipes and tubes; and the requirements for the hydraulic test.

British Standards Institution, 2 Park Street, London, W1.

There is a lot to consider—

Once an electric motor was completely specified by its horse-power and speed. Today, to ensure the efficient operation of modern machines and processes, the correct choice of a motor and its control equipment may involve consideration of many factors.

L.S.E., in addition to making a wide range of standard motors (many of which are available from stock), are equipped for supplying 'tailor-made' drives for the great majority of industrial applications. These may call, for example, for variable-speed, very low speed without mechanical gearing, special mechanical features, enclosures for harmful atmospheric conditions or weatherproof machines to save building costs, and for automatic control gear to operate in conjunction with almost any form of measuring device.

With seventy-five years experience behind them, L.S.E. are useful people to consult when electric motors are under consideration.

LAURENCE, SCOTT & ELECTROMOTORS LIMITED

NORWICH - MANCHESTER - LONDON AND BRANCHES

BUSINESS & PROFESSIONAL

Personal

IN accordance with his announced intention **Mr. John H. Lord** has retired from his executive duties as a managing director of the Dunlop Rubber Company: he will remain a member of the board.

Mr. E. Cars has joined the board of the Moss Gear Company Limited, Tyburn, Birmingham 24, as works director, in place of **Mr. A. W. Macferson** who has taken over the duties of sales director.

DEWRANCE & COMPANY LIMITED, announce that **Mr. Andrew Brown,** formerly chief assistant to the sales manager, Mr. B. S. Bass, has been appointed assistant sales manager. Mr. Brown is closely associated with the sales of special valves designed for service in nuclear power plants.

FURTHER appointments are announced in the new cables division of Siemens Edison Swan Limited, as part of the company's reorganization: **Mr. D. E. Beavan** is home cable sales manager; **Mr. R. G. Holland,** export cable sales manager; **Mr. D. G. Skinner,** telephone cable sales manager; **Mr. H. S. Peet,** distribution equipment sales manager; **Mr. J. A. C. Kendle,** wiring accessories sales manager; **Mr. J. C. E. Coomber,** contract sales manager; **Mr. R. B. Tucker,** assistant home cable sales manager; **Mr. H. E. Helwig,** associations liaison officer; **Mr. P. W. Kilroy,** special projects sales manager.

Colonel J. R. H. Robertson, O.B.E., has been appointed an inspecting officer of railways in the Ministry of Transport and Civil Aviation.

Mr. A. S. Marshall has been appointed to the new post of deputy secretary to Mr. H. E. F. Taylor, secretary of the Electronic Engineering Association, 11 Green Street, W1. Mr. Marshall, who before his retirement from the Royal Navy with the rank of Lt. Commander, was attached to the Admiralty's radio equipment department and the Admiralty Research Laboratory, Teddington, was called to the Bar in 1957.

EDGAR ALLEN & COMPANY LIMITED announce the retirement of **Mr. F. M. Darlow,** manager of the steel department. He joined the Tramway department of the company in 1905. He is succeeded by **Mr. R. E. Sherwood, A.Met.,** who joined the company in 1938 and became assistant manager of the steel department in 1952. The company also announces the following appointments in their subsidiary company, the British "Rema" Manufacturing Company Limited, One Industry Road, Sheffield, 9. **Mr. J. P. Lewis** as general manager. He was formerly sales manager of the parent company's engineering department. **T. R. H. Wadsworth** as assistant general manager. He was formerly chief draughtsman of the combined drawing offices of both the parent company and the British "Rema" Manufacturing Company Limited.

ACHESON INDUSTRIES (EUROPE) LIMITED announce that **Mr. C. R. Wills, B.Sc.Eng. (London),** has been appointed general manager of Acheson Colloids Limited, Plymouth.

Mr. P. A. F. Fuller has joined Dewhurst & Partner Limited, Hounslow, automatic electric control gear specialists, as manager of their components division. He was formerly sales manager with Electron (London) Limited.

Mr. Derek Latham has been appointed to Brook Motors' Birmingham office as a sales engineer.

LANCASHIRE DYNAMO HOLDINGS LIMITED, announce the appointment of **Mr. D. C. Lorkin, F.C.I.S.,** previously joint managing director with **Mr. S. F. Steward, C.B.E.,** as the managing director of the company. This appointment is consequent upon Mr. Steward's resignation of the position of joint managing director of the company and his appointment as director-designate of B.E.A.M.A.

Mr. A. V. J. Wilton was presented with a cheque on his recent retirement as chief purchasing officer of the Siemens Edison Swan Group. **Mr. F. B. Lee** has been appointed assistant sales manager to Mr. F. Bannister, home and export sales manager of Siemens Edison Swan Limited, Ponders End.

Mr. Norman A. G. Dann, for many years manager of the Birmingham branch of Buck & Hickman Limited, has been appointed to the board of directors.

DUNLOP COMPANY LIMITED, announce the following new appointments in their belting division: **Mr. T. A. Brooke** becomes works manager at the Speke factory with overall responsibility for production and engineering work in the division; **Mr. E. Harrison** is appointed production manager; and **Mr. P. J. Bawcutt,** methods and equipment manager.

Mr. D. G. Ashton Davies has now taken up his appointment as sales manager of the Instrument Division of E.M.I. Electronics Limited. Another new appointment is that of **Mr. Charles Kramskoy** who now becomes chief engineer of the commercial division.

Mr. W. Wanstall has been appointed sales and technical service representative by Chloride Batteries Limited, Grosvenor Gardens House, Grosvenor Gardens, London, SW1, to cover the territories of East and West Africa.

Mr. Arnold Carr, deputy chairman of Thos. W. Ward Limited, Albion Works, Sheffield, has been appointed chairman of three Ward subsidiaries. Thomas Smith & Sons (Rodley) Limited, Rodley, Nr. Leeds, excavator and mobile crane manufacturers, John Smith (Keighley) Limited, Keighley, Yorks, makers of overhead travelling cranes, and Widnes Foundry & Engineering Company Limited, Widnes, Lancs, makers of iron castings, fabrications, etc. This appointment is consequent upon the death of **Mr. Frank R. Stagg, M.I.Struct.E.,** who was for many years chairman of these three companies.

THE BRITISH THOMSON-HOUSTON COMPANY Limited, Rugby, announce that consequent upon his recent appointment as chairman of the A.E.I. Divisional Management Company Limited and divisional director and general manager of the A.E.I. Heavy Plant Division, **Mr. L. Drucquer** has relinquished his seat on the B.T.H. board. The following retirements are also announced: **Mr. K. R. Hopkirk,** director and chief mechanical engineer after 43 years with the company: **Mr. S. A. Couling, M.I.Mech.E., A.M.I.C.E.,** chief gear engineer, 33 years' service; **Mr. H. S. Holbrook, B.Sc., M.I.E.E.,** the company's consulting engineer on transformers, Rugby, 48 years' service; **Mr. Herbert Dreghorn, B.Sc.,** manager, manufacturing, Rugby Works and sub-factories, 44 years' service; **Mr. G. H. Clipstone,** manager, control sales department, 46 years' service. Mr. Clipstone is succeeded by **Mr. H. Entwistle, B.Sc. (Eng), M.I.E.E.,** who joined the company in 1923 in the apprenticeship course.

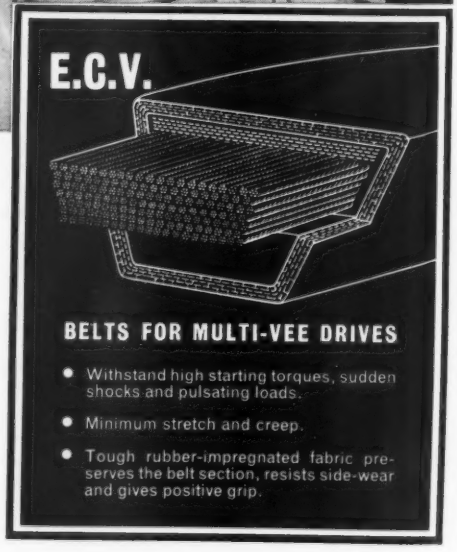
LAST December, after 55 years with Ransomes and Rapier Limited, Ipswich, **Mr. C. N. Jennings,** superintendent of the foundry and pattern shops, retired. At a ceremony to mark his retirement Mr. Jennings was the recipient of several presents.

VICKERS LIMITED announces that **Mr. Reginald C. Pearse** has been appointed an additional director of Canadian Vickers Limited with effect from November 24, 1958, and to the office of president of that company with effect from January 1, 1959. Mr. Pearse will be visiting the establishments of the Vickers Group in the United Kingdom during the next few months and will take up his duties as president of Canadian Vickers Limited on May 1, 1959. The company also announces the following

Greater V-Belt reliability means more productivity

YOU CAN'T RISK costly shutdowns on full-scale production jobs – that's why Goodyear belts are the wisest choice for Multi-Vee drives. They can be fitted and forgotten – there's no better testimony to their trouble-free operation! There's a range of these 'job-designed' Goodyear V-Belts to give longer service and more efficient transmission on every type of drive.

The Goodyear Technical Man will gladly advise on the right belt for any job.



GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

CONVEYOR BELTING · V-BELTS · TRANSMISSION BELTING · HOSE

changes in organization: **Lieutenant-Commander R. B. Lakin, D.S.O., D.S.C. and bar, R.N. (Retd.)**, has been appointed a special director of Vickers-Armstrongs (Engineers) Limited and deputy general manager of the Elswick, Scotswood and Wakefield works of that company. He has relinquished his seat on the board of George Mann & Co. Limited. **Colonel H. S. J. Jelf, C.B.E.**, has been appointed a director of George Mann & Co. Limited and managing director of that company in succession to Lieutenant-Commander Lakin.

Mr. J. G. P. Anderson, B.Sc., F.Comm.A., A.M.I.E.E., A.M.B.I.M., has been appointed manager of the development and research department of Crompton Parkinson Limited. Mr. Anderson joined the company in 1939 as a graduate apprentice.

Mr. George William Riley, M.I.Chem.E., has retired from the boards of George Scott and Son (London) Limited and Ernest Scott and Company Limited after 60 years continuous service. He will, however, be available as technical consultant.

LANCASHIRE DYNAMO announce the appointment of **Mr. R. A. Bent, A.M.I.E.E., A.M.Brit.I.R.E.**, to the board of Lancashire Dynamo Holdings Limited. Mr. Bent is managing director of Lancashire Dynamo Electronic Products Limited, Rugeley, a company of which he was one of the founders in 1946.

Mr. J. A. Hayward, who, since demobilization from the R.A.F. in 1946 has been serving the Firth Cleveland Group as a director of overseas companies in South Africa, West Indies, U.S.A. and Canada, has now in addition been appointed to the board of Firth Cleveland Limited, 8 Cleveland Row, SW1.

THE 1959 James Watt International Medal of the Institution of Mechanical Engineers was awarded to **Sir Claude D. Gibb, K.B.E., D.Sc., F.R.S., etc.** on January 23, but his sudden death necessitated arrangements for the transmission of the medal to Lady Gibb.

THE Benjamin Franklin Medal for 1959 was awarded by the Royal Society of Arts to **Mr. H. S. Nelson, M.A., M.I.C.E., etc.**, managing director of The English Electric Company Limited, "for his work in scientific industrial development".

LANDMASTER LIMITED, Hucknall, Nottingham, a member of the Firth Cleveland group, announce the appointment of **Mr. J. E. Bryden** as home sales manager, in which capacity he will assist **Mr. F. Bedworth,** home sales director. **Mr. A. P. McNeil-Smith** has been appointed to the sales staff and his duties will include show and exhibition administration, together with general sales promotion for Gardenmaster rotary cultivators.

Mr. Cecil Dotson of Dallas, Texas, U.S.A., has been appointed chairman of the board of Texas Instruments Limited, Bedford—first European subsidiary of the American organization and largest manufacturers of silicon semiconductors (transistors) in this country.

METROPOLITAN - VICKERS ELECTRICAL Company Limited, announces the appointment as from January 1, 1959 of **Mr. H. West, Assoc.M.C.T., Hon.M.Sc.(Manchester), M.I.Mech.E., M.I.E.E., Member A.M.E.M.E.**, as assistant managing director. The company also announce the appointment of **Mr. J. W. Potter, A.C.I.S., A.A.C.C.A.**, formerly assistant secretary, as secretary in succession to **Mr. D. Thomson,** retired.

THE GENERAL ELECTRIC COMPANY LIMITED has made the following appointments at its Erith works: works superintendent, **Mr. S. W. Hyde;** works manager, **Mr. F. J. Beesley;** production manager and assistant works manager, **Mr. W. E. J. Rees.**

TECALEMIT of Plymouth, announce the following U.K. sales appointments: **Mr. R. R. Parker** becomes general sales manager, **Mr. S. C. Kennett,** formerly manager of the northern sales region based at Wetherby, Yorks, is appointed deputy general sales manager. **Mr. D. M. Bruce** has been appointed marketing manager. He will also continue as editor of "Tecalemit News".

Mr. Matthew Hudson has joined the staff of Rockweld Limited as an automatic welding engineer, responsible for preparing schemes in the application of the Rockweld Autopak automatic welding equipment.

Sir Gordon Russell, C.B.E., M.C., R.D.I., F.S.I.A., has decided to retire from the directorship of the Council of Industrial Design on December 31, 1959, when he will be sixty-seven years of age. The Council has accepted this decision with reluctance and with the keenest appreciation of the great contribution Sir Gordon has made to its work throughout its entire life. He was an original member of the council when it was set up in 1944 and was appointed its director in 1947. The Council has appointed **Mr. Paul Reilly,** who joined the staff in 1948 and has been deputy director since 1954, to succeed Sir Gordon Russell on January 1, 1960.

Mr. D. G. Haigh, M.I.E.E., has been appointed export manager of Chloride Batteries Limited. He is now responsible for ensuring co-ordination of export marketing.

Mr. J. E. Odgear, manager of the Exide stores and assembly works has retired after 40 years' service. He was presented with a radiogram on behalf of members of the staff by Mr. C. G. F. Pritchett, director and general manager of the company.

Mr. Tom Nethersole, sales manager at Ferrybridge office of the Philidas locknut division of Whitehouse Industries Limited, has now taken over the company's sales organization throughout London, Middlesex, Surrey, Kent and Sussex. He can be contacted through the London office of the company, 44 Hertford Street, W1. Telephone Legation 3888.

Addresses

S. N. BRIDGES AND CO. LIMITED have opened another branch office and service depot at 19 Eastgate, Leeds 2, and will carry a permanent window display to assist their local dealers. The new branch is under the management of Mr. D. Noble, formerly service foreman at Manchester, and is fully equipped to carry out all repairs and supply any new parts required. The telephone number is Leeds 31656/7.

E. P. BARRUS (CONCESSIONAIRES) LIMITED, of 12–16 Brunel Road, Acton, London W3, have opened a branch in Manchester at Deansgate House, 274 Deansgate, Manchester 3. Barrus industrial lines include Cleveland drills and tools, Devcon the Plastic steel, Blackhawk Porto-Power hydraulic equipment, Porter bolt cutters and tools, and Nicholson files for which they have been recently appointed distributors.

METAL INDUSTRIES LIMITED are now in their new premises at Brook House, Park Lane, London W1. Telephone: Hyde Park 6770.

THE sales departments of Furnival & Co. Limited, Engineers, Waterloo Engineering Works, Stockport, have been transferred to Rhodes, Brydon and Youatt Limited, the parent company's offices at Waterloo Engineering Works, Stockport, Cheshire. Other departments, including the accounts department of both companies are now situated in the Reddish Works, telephone number HEAton Moor 4228. With the expansion of company's interests, two distinct internal divisions have been formed, one to deal with the sale of printing and paper cutting machinery and the other with the marketing of the patent Andantex reduction pulleys.

NELDCO PROCESSES LIMITED are now in their new offices at Crossways House, Bracknell, Berkshire. Telephone: Bracknell 1789.

THE INSTITUTION OF PLANT ENGINEERS is the new title of the former Incorporated Plant Engineers.

BROOK MOTORS LIMITED sales office in Sheffield has now removed to larger premises at Saxone House, 4 George Street. The telephone number remains the same, Sheffield 28477–8.

THE offices and warehouse of Griffin & George (Sales) Limited, laboratory furnishers at Cheetham Hill Road, Man-

Resistance Heating-1

In this form of heating, the heat is produced by passing an electric current through a high resistance conductor which is termed the " heating element ".

The heat is transferred from the heating element to the work by convection, radiation or conduction, or by a combination of any, or all of these. When it is a question of radiation or convection, the element can be a bare wire or strip of suitable material, provided it is adequately supported on electrical insulation capable of withstanding the temperature.

When there is to be contact between the work and the element, heat being transferred to the work by conduction, the wire or strip must be surrounded by suitable insulating material and enclosed in a protective sheath.

In the majority of cases, the wire or strip forming the heating element is made of a nickel-chromium alloy which has a high electrical resistance and can be safely used in air at temperatures of up to 1050°C., or in a suitable atmosphere, of up to 1150°C. Other element materials are available for use at higher temperatures.

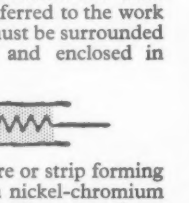
Sheathed elements, essential for contact heating but also used widely for convection and radiation heating because of the convenience afforded by the mechanical strength of the sheath, usually metallic, and by their "built-in" electrical insulation, cannot be used at temperatures as high as the bare wire or strip. This is because the wire, being embedded in insulation, is always at a higher temperature than the sheath, and to keep the wire temperature down to a safe figure the sheath temperature is usually limited to a maximum of around 800°C.

Automatic temperature control of resistance heating elements within narrow limits is easily effected, but if manual control only is desired, devices are available which enable the heat output of the elements to be controlled precisely at a required level. As with all electrical methods, a time switch may be included in the control circuit for automatically switching on or off at predetermined times, and this can enable, for example, an electric oven to be fully up to working temperature by the time the working day starts. Since there are no combustion products from the heaters, there is no need to build flues or special ventilating arrangements which also carry away useful heat.

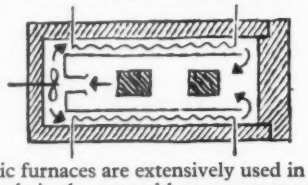
Electric resistance heating may profitably be put to many diverse uses; two of these are described briefly below, others will be listed in a subsequent data sheet.

Furnace Heating

Electric resistance furnaces can be divided into two main categories, batch type and continuous. In most cases, the heating elements are of nickel-chromium alloy, for furnace temperatures up to around 1050°C., but higher temperatures, up to nearly 3000°C., can be obtained by using other metals or alloys, or in some cases non-metallic elements. A protective atmosphere is desirable to prolong the life of some of these higher-temperature elements. For all temperatures, electric resistance furnaces can be constructed so that the heating process takes place in a controlled atmosphere if this is dictated by the composition or heat requirements of the work charge. In some furnaces, fans are used to circulate the air or special atmosphere over the charge, thereby giving increased heating rates and a uniform temperature over the whole charge.



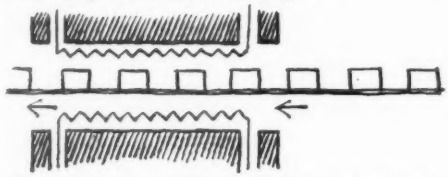
Automatic temperature control and program control of the heating process are readily effected.



Electric furnaces are extensively used in industry, for example in the general heat treatment of metals, in the glass and ceramics industries, for brazing and sintering, and for many other applications requiring temperatures above 500°C.

Oven Heating

There are two basic forms of heat transfer used in electric resistance ovens: convection and radiation. The latter is dealt with in a separate data sheet under the heading " Infra-Red Heating ".



Convection ovens may again be of the batch or continuous type. In either case, the charge is heated mainly by the movement of hot air, which is sometimes assisted, as in furnaces, by fans to give a rapid and uniform temperature rise. Ovens are normally designed for temperatures of up to about 500°C., and the heating elements are invariably of nickel-chromium or nickel-chromium-iron alloy.

Ventilation, when required, can be provided and regulated entirely to suit the heating process. Temperatures and times are readily controlled. A vacuum can be maintained in suitably designed ovens to assist in the extraction of moisture and solvent.

Convection ovens are extensively used for drying, baking and stoving operations, and for a host of other processes requiring a low or medium temperature.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, W.C.2.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

6780C

chester 4, are now connected to the Telex system on Telex 66–450.

PRAT-DANIELS (STROUD) LIMITED of Whitecroft, Nailsworth, Stroud, Glos., makers of fans and grit and dust collectors, have moved from their London office at Westminster Palace Gardens, Victoria Street, SW1. The London office of the Daniels group which includes T. H. & J. Daniels Limited, British Boiler Accessories Limited and Prat-Daniels (Stroud) Limited, is now situated at 62-3 Fenchurch Street, London EC3, telephone: Royal 4122–6305. Mr. A. O. R. Johnson, managing director of T. H. & J. Daniels Limited has joined the board of Prat-Daniels (Stroud) Limited.

THE Birmingham, Glasgow and Manchester offices of The English Electric Company Limited have been connected to the national Telex service. The office numbers are as follows: Birmingham branch office, No. 33177; Glasgow branch office, No. 77423; Manchester branch office, No. 66428.

SIMMS MOTOR UNITS LIMITED have acquired the business of Smith's Electrical Service Station, 25 London Road, Carlisle. This new branch of Simms Motor Units Limited will be under the management of Mr. E. Dorning, formerly motor trade manager of the Manchester branch of the company.

THE address of British Insulated Callender's Cables Limited branch office at Derby is now Hartington Street, Derby. The telephone number remains the same, Derby 41421. New premises have been acquired for the Cardiff branch at Station Terrace, Queen Street. The Gloucester branch has acquired an additional telephone exchange line, Gloucester 21377.

PRESSED STEEL SOCIETE ANONYME, with headquarters at Galerie Ravenstein 30, Cantersteen 7, Brussels 1, has been formed to represent the Pressed Steel Company in the Common Market countries.

THE Griffin and George group have formed a new company, Griffin & George (Research and Development) Limited, in connexion with scientific instruments and apparatus for laboratory use and process control.

LANDMASTER LIMITED have formed an Australian subsidiary, Landmaster Pty. Limited. The Australian subsidiary of Simmonds Aerocessories Limited will manufacture at Ballarat certain products for the Landmaster company.

A NEW Belgian company, Cobenam S.A., has been formed jointly by Union Carbide and Societe Chimique des Derives du Petrole, S.A. (Petrochim) to manufacture polyethylene.

A NEW company, Preformations Limited, has been formed by The Plessey Company to manufacture magnets in agreement with the Arnold Engineering Company of Illinois, under the trademark "Magloy".

THE HOLBROOK MACHINE TOOL COMPANY Limited, makers of precision lathes, has been acquired by Alfred Herbert Limited.

W. H. DORMAN & CO. LIMITED have taken over control of W. G. Bagnall Limited, Stafford, from the Heenan Group Limited.

A NEW Indian company, Acc-Vickers-Babcock Limited, formed by Associated Cement Companies of India (ACC), Vickers Limited, Babcock and Wilcox Limited, and other Indian interests, is to manufacture heavy engineering products in West Bengal. The registered offices are at 119 Queens Road, Bombay.

COOKE, TROUGHTON & SIMMS LIMITED of the Vickers Group have acquired the optical instrument makers, C. Baker of Holborn Limited, the name of which is eventually to be changed to C. Baker Instruments Limited.

ROAD MACHINES (SALES) LIMITED has been formed by The Muir Robb Group, Horton Parade, West Drayton, and will absorb the existing home and export departments.

STEEL & CO. LIMITED, Sunderland, have acquired F. Taylor & Sons (Manchester) Limited makers of the Taylor Jumbo mobile crane.

Contracts and Work in Progress

LEYLAND MOTORS LIMITED.—£70,000 contract from Ceylon Transport Board for 36 Leyland Comet passenger chassis, bringing the total value of orders from the Board to £900,000.

Contract for the supply of 60 diesel-engined road tankers valued at over £250,000 from the National Iranian Oil Company.

BRITISH OXYGEN LINDE LIMITED.—Contract for a tonnage oxygen plant worth nearly £750,000. Placed through Humphreys and Glasgow Limited who are building the Lurgi pressure gasification plant at Westfield, Fife, for the Scottish Gas Board.

WILD-BARFIELD ELECTRIC FURNACES Limited.—Further order for 750 lb capacity mains frequency induction heated aluminium holding furnaces from U.S.A. organization.

THE HUNSLET ENGINE COMPANY LIMITED, 125 Jack Lane, Leeds 10.—Contract approaching £500,000 from British Railways to supply a further 33 shunting locomotives.

E.M.I. ELECTRONICS LIMITED.—Order from Imperial Chemical Industries for Emidec 1100 electronic computor at Welwyn Garden City.

ROBERT HARLOW & SON LIMITED, Stockport.—Consignment of Fullway valves and 2 in. full bore cocks completed and shipped for the Seychelle Islands.

TAYLOR WOODROW CONSTRUCTION Limited.—Contract of nearly £400,000 value awarded by the Wellcome Foundation Limited at Langley Court, Beckenham, Kent, for the construction of a reinforced concrete research building.

METROPOLITAN - VICKERS ELECTRICAL Company Limited.—Supply of 124 sets of electrical equipment for British Transport Commission Liverpool Street/Southend conversion scheme.

SIEMENS EDISON SWAN (EXPORT) LIMITED.—Contract worth £26,000 for p.v.c. insulated cables for the Damodar Valley Corporation, India.

Computor Courses

THE establishment of courses in the uses of commercial computors is a necessary outcome of the increasing interest in these specialized additions to office machinery. Two courses each of five days' duration are announced by Urwick Diebold Limited, the recently formed British firm of data processing consultants. The courses will be held in London during February and March and are designed for managers and executives. Details may be had from Urwick Diebold Limited, 29 Hertford Street, London, W1.

Oil-firing Course

A FURTHER three-day course on oil-firing has been arranged at N.I.F.E.S. Office, Ailsa House, Kings Road, Reading, on April 14, 15 and 16, 1959. As some of the places have been taken up by those who could not be accepted into the January course, early enrolment is recommended. Application forms and syllabus may be obtained from the National Industrial Fuel Efficiency Service, 71 Grosvenor Street, London W1. (Telephone: Hyde Park 9706.)

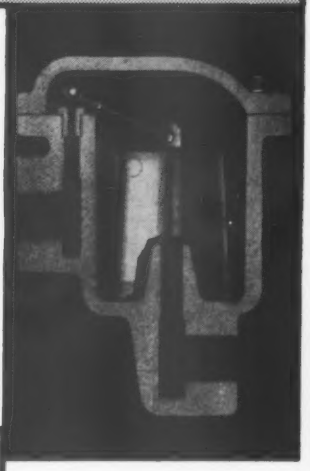
Physical Instrument Awards

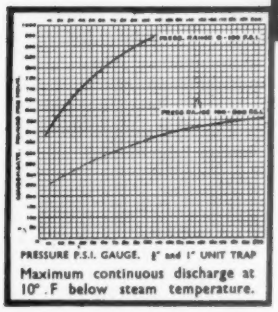
THE ROYAL SOCIETY announce that awards of grants by the Paul Instrument Fund Committee have been made as follows: £3835 to Professor A. L. Cullen, professor of electrical engineering in the University of Sheffield; £545 to Dr. R. Feinberg, of the electrical engineering department, Manchester College of Science and Technology; £1000 to Mr. R. M. Sillitto, lecturer in natural philosophy, University of Edinburgh. The Paul Instrument Fund Committee was set up in 1945 to receive applications for grants from British subjects who are research workers in Great Britain.

"The Lancaster"

REG. TRADE MARK

UNIT STEAM TRAP





PRESSURE P.S.I. GAUGE. ½" and 1" UNIT TRAP

Maximum continuous discharge at 10° F below steam temperature.

. . . A NEW TRAP BY AN OLD MAKER

IT'S SMALL
IT'S EFFICIENT
IT'S LOW IN PRICE

Particularly suitable for use with Unit Heaters, Laundry Calenders, Tumblers, Presses, etc. Calorifiers, Heated Cavity Tables, Sterilisers and anywhere where unit trapping calls for a number of small inexpensive steam traps.

PRESSURE RANGES: 0-100 P.S.I. sat, and 100-200 P.S.I. sat.

MADE IN THREE SIZES: ½ in., ¾ in. and 1 in. B.S.P. or A.P.I.

Self-supporting on the pipe-line

For further details ask for List No. 98.

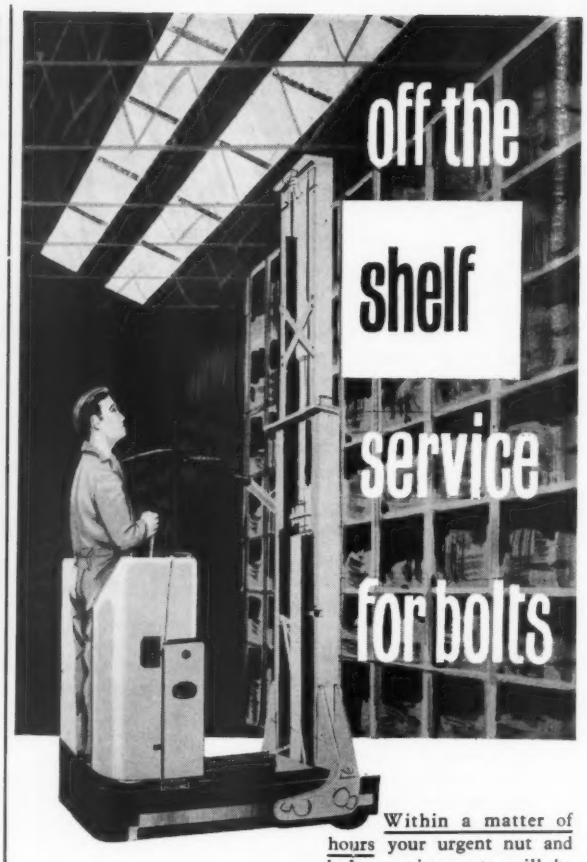
The maximum continuous discharge of the ½ in. trap is approx. half the discharge shown on the graph.

We also manufacture Separators, Pumping Traps, Steam Traps for all purposes, Strainers, Metallic Packings, etc., etc.

LANCASTER & TONGE LTD

PENDLETON · MANCHESTER · ENGLAND

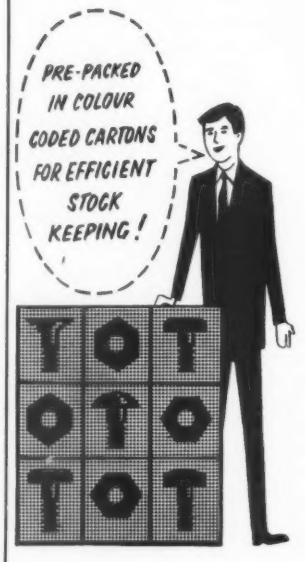
Telephone: Pendleton 1484/5/6 · Telegrams: "Pistons, Manchester"



off the shelf service for bolts

Within a matter of hours your urgent nut and bolt requirements will be supplied via the re-organised and super-efficient stock and despatch department at LANARKSHIRE BOLT.

A most comprehensive range of sizes in black, bright, high tensile, and many other metals can be sent by return. And if it's convenient you can collect your order self-service style. Specials? Certainly! And again with little delay.



Do you get our MONTHLY STOCK LIST?

Save time wasted in chasing supplies by asking for our FREE stock list, mailed every month to interested buyers Please send name on firms letterhead to

LANARKSHIRE BOLT LIMITED

Hamilton, Lanarkshire, Scotland. Tel. 1241-4.

New Lockheed Company

A NEW company to be known as Lockheed Precision Products Limited, has been formed by Automotive Products Associated Limited, London. This move is designed to further the company's policy of decentralization. The company has design and manufacturing facilities already available at the group's factory at Speke, Liverpool, and will manufacture and sell aircraft and industrial hydraulic equipment and Lockheed-Avery hoses and couplings.

Royalties Payments

THE Board of Trade announce that an Agreement signed with the Government of the French Republic came into force on November 28 under which, on certain conditions, exemption is granted from payment of the French turnover tax on royalties to United Kingdom inventors (whether individuals or firms) who have licensed the use of their inventions in France. Copies of the text of the Agreement are available on request from Mr. D. Mellor, Board of Trade, Room 4158, Horse Guards Avenue, London, SW1. (Telephone No. Trafalgar 8855, Ext. 2421).

Simmonds German Subsidiary

THE formation in Germany of Deutsche Firth Cleveland GmbH, as a subsidiary company of Simmonds Aerocessories Limited, a member of the Firth Cleveland Group was recently announced. The new company has been set up in anticipation of the establishment of the Common Market and the Free Trade Area, and it will undertake the marketing in Germany of most of the products of Simmonds Aerocessories Limited made at Treforest, Glam., as well as those made by Simmonds British subsidiary—Firth Cleveland Instruments Limited. Mr. A. A. Puth has been appointed general manager of Deutsche Firth Cleveland GmbH., assisted by Mr. H. Seiler as Surform Sales Manager. Offices are at Neckarauerstrasse 245-53, Mannheim (Telephone: Mannheim 41458, Telegraphic addresses: "Aerocessim, Mannheim" and "Fircleve, Mannheim").

Cheaper Electric Motors

A REDUCTION in price of 10% on electric motors type KFB of 2, 4, 6, and 8 poles up to 25 h.p. was recently made by The British Thomson-Houston Company.

Agents and Distributors

THE following area distributors have been appointed by Joy-Sullivan Limited for "Limberoller" conveyor idlers. Potter Cowan & Co. Limited, Glasgow; Glover & Wood Limited, Leeds 11; Rolkin Shakeshaft Limited, Broadheath, Altrincham; Central Manufacturing & Trading Company (Dudley) Limited, Old Hill; Compressed Air Services (Bristol) Limited, Bristol 4; Southern Industrial Rubber Limited, South Norwood, London SE25.

DISTRIBUTION in the U.K. and Eire of Dagenite motor batteries is now being undertaken by the manufacturers, Pritchett & Gold and E.P.S. Limited.

DURHAM RAW MATERIALS LIMITED, 1–4 Great Tower Street, London EC3 are sole selling agents in the United Kingdom for Schule filter presses.

ALBRIGHT AND WILSON (MFG.) LIMITED have installed two additional plating tanks for the increased production of Kanigen plated components.

Trade Literature

Fabric Reinforced Resin Bushes

The properties of Orkot a fabric reinforced resin material made by United Coke and Chemicals Company, Limited, are given in a leaflet issued by The United Steel Companies Limited, 17 Westbourne Road, Sheffield, 10. It has already been proved successful as a material for rolling mill bearings and more recently, it has been used in the manufacture of bushes, for arduous machinery duties. Typical applications include suspension bushes, conveyor rolls, scale breaker roll bushes and pickling plant roller bushes.

Polyethylene Film

Film made from Rigidex Polyethylene is claimed to have a higher softening point than conventional polyethylene and superior tensile strength. It has excellent resistance to grease and oils and its permeability to moisture and most gases is low. The film does not "block" and can be easily processed on automatic machinery.

Extrusion conditions for the production of Rigidex film and the properties of blown and lay flat film are given in Technical Information Sheet No. 6, issued by British Resin Products Limited, Devonshire House, Piccadilly London, W1., from whom copies are obtainable on request.

Thermal Insulation of Buildings

It is estimated that of the 30% of fuel used in industry for space heating some 50% of the resulting heat is lost through factory walls and roofs. Obviously some method of thermal insulation must be adopted if heating efficiency is to be improved and in a leaflet issued by W. H. Heywood & Company Limited, Bayhall Works, Huddersfield, their under-purlin system of board fixing using steel or aluminium-alloy T sections with insulating board, asbestos-cement wallboard, plasterboard, etc., for the thermal insulation of corrugated asbestos-cement or metal roofs and walls is described. The system is applicable to flat or curved roofs and may be used for suspended ceilings.

Ultrasonic Cleaning and Machining

New developments in the industrial application of ultrasonics are featured in a leaflet produced by Kerry's (Ultrasonics) Limited, Warton Road, London E15, who offer a comprehensive range of ultrasonic cleaners from a small bench model up to a large automatic conveyorized plant. Machining equipment includes ultrasonic drills, engraving tools, tapping, lapping and reaming units and also units for soldering and tinning.

Folding Hydraulic Lifters

Hydraulic lifters of up to 10 ton capacity which will fold down to 9–18 in. are shown in a leaflet from Access Equipment Limited, Maylands Avenue, Hemel Hempstead, Herts. These Bicep lifters are particularly suitable for industries handling large quantities of heavy sheet materials.

Permanent Magnet Summarized

A handbook of the above title has recently been compiled by F. G. Tyack, A.M.I.E.E., technical sales manager of the industrial permanent magnet division of James Neill & Company (Sheffield) Limited, Sheffield 11, the makers of Eclipse permanent magnets as a guide to the design and application of permanent magnets. The publication is intended to be essentially practical and is therefore devoid of any catalogue material. A wealth of illustrations and diagrams support the text which is sectioned for ease of reading.

The sections include the theory of magnets, magnetic circuits, magnet materials, machining mechanical and electrical applications.

Starters for A.C. Motors

A brochure showing various types of electrical control gear, has been issued by Brook Motors Limited, Empress Works, Huddersfield, and is entitled Brook Starters.

Its contents include lists of starters and a section on control gear maintenance.

Turbines and Rail Traction Equipment

The full range of products manufactured by Brush Electrical Engineering Company Limited, Loughborough is displayed in their latest products book. It includes turbines, turbo-alternator sets, power and distribution transformers, H.V. and L.V. switchgear, fusegear and H.B.C. fuses, a.c. and d.c. motors and generators, diesel-electric locomotives and rail traction electrical equipment.

Idlers for Belt Conveyors

The latest catalogue issued by the Publicity Department, Mavor & Coulson Limited, Farme Cross, Rutherglen, Glasgow, describes their grease sealed idler rollers. Full tables of sizes and weights, illustrations of applications and sections showing the construction of the idlers are given. The types include idlers for belts from 14 to 60 in., cushion rollers, steering idlers for reversible belts, idlers for picking belts, return idlers and inverted troughing for carrying the idlers. A chart gives the width and speed of belts for conveying any of six weights of material at any required rate.

Valve Springs

A brochure issued by Cockburns (Springs) Limited, 91 Meiklewood Road, Cardonald, Glasgow SW2 is to announce the production equipment and resources of this new subsidiary of Cockburns Limited.

New Factories

Darlington. North-Eastern Trading Estates, Limited. Plans are being prepared by Fennell and Baddiley, Bridge End Chambers, Chester-le-Street for extending factory on Aycliffe trading estate.

Durham. Mackay & Company Limited, carpet manufacturers. Work is to start on factory extensions of about 10,000 sq ft. The contract for the reinforced concrete frame has been let to Holst & Company, Waddington Street, Durham, and the general building contract will be settled soon. The architects are Cordingley and McIntyre, Owengate, Durham.

Easington. Northern General Transport Company Limited, Murton. The tender of Bewley & Scott Limited, Dunston-on-Tyne, has been accepted for proposed extensions to garage and workshops.

Eston (Co. Durham). South Durham Steel and Iron Company Limited, Middlesbrough. A scheme for the erection of new coke-ovens at South Bank-on-Tees has been approved.

Gateshead. British Road Services, Limited 150 Goswell Road, London, E.C.1. are to erect service station, stores, offices, boiler-house, etc., at Eastern Fields Depot, Team Valley trading estate, and have prepared their own plans.

Hartlepool. Paragon Limited. Plans have been prepared by Newrick and Blackbell, 58 John Street, Sunderland for factory extensions (19,000 sq ft.).

Longbenton. C. A. Parsons and Company Limited, Newcastle upon Tyne. Work has started on the erection of a factory at Forest Hall. The contractors are Sir R. McAlpine & Sons Limited, 81 Jesmond Road, Newcastle upon Tyne.

Middlesbrough. Rea's Limited. Ice cream factory in Longlands Road, to be erected by T. A. Crawford, 80 Borough Road.

Newcastle upon Tyne. C. A. Parsons and Company Limited, Heaton, are to erect despatch and packing case shop, and panel shop at their works, and have prepared their own plans.

Ryton (Co. Durham). The North-Eastern Electricity Board, 80 Jesmond Road, Newcastle upon Tyne are to erect head-quarters stores, offices, workshops and garage at Crawcrook, and have prepared their own plans.

South Shields. S. Newman Limited. Factory extensions in Commercial Road are to be carried out by North-Eastern Trading Estates, Limited, Gateshead.

Wigton (Cumberland). Bri ish Rayophane Limited, are planning extensions to their works at Wigton.

Acton. Henderson Engineering Limited, 15 Enfield Road, London, W3. A new factory is to be erected at Colville Road.

Bolton. Smithills Engineering Company Limited are to extend their works in Endon Street.

Bournemouth. Aerograph De Vilbiss Company Limited, Kangley Bridge Road, Sydenham are to erect a new factory at West Howe.

Bradford. H. C. Slingsby Limited, Preston Street are to build a new workshop and offices.

Brighouse. Mellors Limited, Mill Royd Street, are to extend their Alexandra Mills.

Bristol. British Metal Components Limited. New factory and offices are to be erected in Whitefield Road.

The Victoria Motor Company Limited, are to carry out industrial development in the Temple Gate and Chatterton Square areas.

Burnley. Burco-Dean Limited, are to erect a new factory near Gannow Lane (Maden Fold).

Chatham. W. J. Mackay & Company Limited, Fair Row. Extensions are to be made to the printing works.

Coventry. H. L. Bates & Son, Limited, 3 Arbury Avenue are considering the erection of a new factory at Broad Lane industrial estate.

Croydon. Airlite Pressed Products Limited, 62 Windmill Road. The architect for extensions to the works is D. V. Blythe, 98 Parchmore Road, Thornton Heath.

Dewsbury. Newlay Concretes Limited. Extensions are to be made to Thornhill Works, Calder Road.

Dundee. Morphy-Richards Limited, 6 Conduit Street, London, W1, are to build another large factory.

Folkestone. Martin Walke Limited, Sandgate Road, are to extend their Tile Kiln Lane factory.

Falkirk. George Inglis & Company Limited, Howgate, are to make extensions to their printing works.

Halifax. Ada (Halifax) Limited, West Mount Works, Johnson Street, are to erect works extension at Beech Hill.

Hendon. Neuberger Products Limited. Extensions are to be made to the factory in Rushgrove Avenue, London, NW.

Hull. Parsons Bros. Limited. Extensions are to be made to the factory in Froghall Lane.

Humber Oil Company Limited, Marfleet Lane factory is to be extended.

London. C. A. Courts & Company. New factory and offices to be erected at Brewery Road, Islington. Hastie, Winch & Kelly, 1 Bentnick Street, London, W1 are the architects.

Loughborough. Wills & Hepworth Limited. Extensions are to be made to the printing works at Angel Yard, Market Place.

Mansfield. Janfrey (Mansfield) Limited, are to erect their factory at Thoresby Street and Lindley Street.

Norwich. Balding Engineering Company Limited, Beaver Works, Bessemer Road, are to erect a new factory at Drayton Road and Sweet Briar Road.

Nuneaton. De Mulder & Sons, St. Mary's Road, are to make extensions to their factory.

Peterborough. Plasticasts Developments Limited. Fosters & Rudd Limited, Wharf Road, Grantham are the contractors for extensions to the factory in Lincoln Road.

Peterhead. Cleveland Twist Drill Limited. The architects for extensions to the works are Allen & Frisken, 2 Castle Street, Dundee.

Portsmouth. A. G. Figgins Limited, Swiss Road, Waterlooville. Extensions are to be made to the factory at Fitzherbert Road.

Redditch. George Horner (Redditch) Limited, are to make extensions to their factory at Hewell Road.

Surbiton. Gatley (Engineering) Limited, Roebuck Road. Factory to be extended.

Swansea. Arthur Thomas & Company (Metals) Limited, 60 Mansell Street. A new factory is to be erected in Slip Road.

H. Steele & Son Limited, are to make extensions to their Albion Works.

Walthamstow. The London Rubber Company Limited, Hall Road, London, E4. Extensions are to be made to the factory in Chingford Mount Road.

West Bromwich. George Salter & Company Limited, High Street. Extensions are to be made to the factory.

Hampson Industries Limited, are to extend their works in Bull Lane.

Wigan. Reed Corrugated Cases Limited, Ayres Road, Trafford Park, are to make extensions to their factory at Goose Green.

Glasgow. William Beardmore & Company Limited, one storey block, East Wellington Street, E.1. for dissolved acetylene work.

Robert Rogerson & Company Limited, 1214 South Street, W4, a two storey workshop.

Thomas Porter Limited, Mafeking Street, SW1, a one storey covered tube store.

Western Regional Hospital Board, a new radio therapy department at Western Infirmary.

John Thompson (Wilson Boilers) Limited, London Road, E1., are adding a one storey extension to their boiler works at Lilybank Boiler Works.

A. W. Smith & Company Limited, are building a boiler house, heating installation and 56 ft high chimney at 120 Tradeston Street, C5.

Ministry of Works are to erect an engineering department at Drakemire Drive, S3., for the Post Office Engineering Section.

The Corporation are to install new heating and ventilating in the Kelvin Hall at a cost of £65,000, scrapping and selling the existing refrigeration plant.

Errata

"Carbide Tipped Circular Saws".—

Reference was made on page 95 of our February issue to Speedicut Mitia carbide tipped saws made by Firth Brown Tools Limited. Their address should have read, Speedicut Works, Carlisle Street East, (P.O. Box No. 59), Sheffield 4.

"Audible Warning of Gamma Radiation".

The name of the firm on page 71 of our February issue should have read Radiatron.

CLASSIFIED ADVERTISEMENTS

Situations Vacant

AUSTRALIA — UNIVERSITY OF QUEENSLAND

READER OR SENIOR LECTURER IN MECHANICAL ENGINEERING

APPLICATIONS are invited for the above position. Applicants should have a Degree or Higher Degree in Engineering of a recognised University together with design experience in industry and teaching experience at University level in design subjects. The appointee wil be required to take charge of the design side of the course, in which he would be assisted by other lecturers, dealing with Mechanical Engineering students at all levels and students of other engineering and allied subjects in earlier years of the course. An interest in research is desirable.

Salary £A2560/£A2800 p.a. or £A2160/£A2510 p.a.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. or from the registrar, University of Queensland, Brisbane, Queensland, Australia.

Applications close, in Australia and London, on **10th April, 1959.**

Machinery, Plant and Accessories For Sale

SECTION ROLLING MACHINES FOR SALE
ROBERTSON 7-STAGE SECTION FORMING MACHINE

FOR SALE with additional curving unit. Specially suitable for profiling and bending stainless steel sections. Drive is by 20 h.p. motor through 3-speed gearbox. Diameter of roller shafts 2". Length of shafts available for forming rollers $8\frac{7}{8}$". Rolling speeds with 6" diameter rollers, 40, 80 and 120 feet per minute. Weight about $11\frac{1}{2}$ tons. Full details and illustrations from F. J. Edwards, 359-361, Euston Road, London, N.W.1. or 41, Water Street, Birmingham, 3.

FOR SALE. 10 Water Coolers, Makers Holden & Brooke, horizontal type. Overall dimensions 12′ 6″×4′ dia., Shell and Cover welded construction. Capacity 810 Galls per minute. Water from 110° F to 90° F, suitable for working pressure of 100 lb per sq. inch. Each contains nest of 1280 Steel Tubes 8′ long $\frac{3}{4}$" o.d. and 16 swg. Recently left off working. Apply: Thos. Jenkins & Son Ltd., Exchange Buildings, Port Talbot.

FREELANCE wanted, alive to sales potential of VW engine to Site Contractors. Box No. FW 14, "Mechanical World," 31 King Street West, Manchester 3.

"FRIGIDAIRE" Low Temperature Refrigerators. 49 in.w × 28 in.d × 34 in.h ext. Ex Large National User, suitable A.C. or D.C. Deep Freezing, Storage of Ice Cream, Frozen Foods, etc. Price £40.0.0 each. Domestic Refrigerators, Service Cabinets and Cold Rooms also available. A.R.C., 134 Great Portland Street, London W1. MUSeum 4480.

FANS! ! ! for Dust, fume extraction, air conditioning, compressors, accessories, motors, etc.; at considerably reduced prices. People say—"If only we'd known of you before. . . . Write for very interesting list. Bellangers, 306 Holloway Road, London N7. North 4117.

PUMPS for all purposes. R. L. Christansen Limited, Wordesley, Stourbridge. Brierley Hill 78184/5.

Patents for Sale or License

THE proprietor of British Patents Nos. 663616 and 663708, entitled "Tanks and the like for spraying liquids under gaseous pressure" and "A closure for sprayer tanks and the like" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 685422, entitled "Improvements in Variable Speed Wire Spray Gun", offers same for license or otherwise to ensure its practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, Chrysler Building, New York 17, New York, U.S.A.

THE proprietor of British Patent No. 644394, entitled "Clamping Band" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 683050, entitled "Hand operated liquid sprayers" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 698498, entitled "Centrifugally controlled variable ratio pulleys", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE proprietors of Patent No. 613055 for "Improvements in or relating to Methods of Infolding and Machines therefor", desire to secure commercial exploitation by license or otherwise in the United Kingdom. Replies to Haseltine Lake & Co., 28 Southampton Buildings, Chancery Lane, London WC2.

THE proprietor of British Patent No. 737352, entitled "Cable Spool Winding", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

THE proprietor of British Patent No. 682213, entitled "Forming Roll Machine", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 East Jackson Boulevard, Chicago 4, Illinois, U.S.A.

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